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ANNUAL REPORT

OF THE

CHIEF OF ORDNANCE

TO THE

SECRETARY OF WAR

FOR THE

FISCAL YEAR ENDED JUNE 30, 1894.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1895.

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REPORT OF THE CHIEF OF ORDNANCE.

WAR DEPARTMENT, ORDNANCE OFFICE,
Washington, October 1, 1894.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1894, with such remarks and recommendations as the interests of this branch of the military service seem to require.

The fiscal resources and expenditures of the Department during the year were as follows, viz:

Amount in the Treasury to the credit of the appropriations on June 30, 1893	$4,348,541.85
Amount in the Treasury not reported to the credit of the appropriations on June 30, 1893	436.04
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1893	553,400.05
Amount of appropriations for the service of the fiscal year ended June 30, 1894	3,123,403.69
Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1894	223,900.12
Gross amount received during the fiscal year ended June 30, 1894, from sales to officers; from rents; from collections from troops on account of losses of or damage to ordnance stores; from Chicago, Rock Island and Pacific Railroad Company; from powder and projectiles (proceeds of sales); from sales of condemned stores; from testing machine, and from all other sources not before mentioned	38,791.21
Total	8,288,472.96
Amount of expenditures during the fiscal year ended June 30, 1894, including expenses attending sales of condemned stores, exchange of powder, etc	4,463,749.98
Amount deposited in Treasury during the fiscal year ended June 30, 1894, as proceeds of sales of Government property	9,610.03
Amount turned into the surplus fund on June 30, 1894	3,473.81
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1894	507,414.97
Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1894	32,427.30
Amount in the Treasury not reported to the credit of appropriations on June 30, 1894	206.28
Amount in the Treasury to the credit of appropriations on June 30, 1894	3,271,590.59
Total	8,288,472.96

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CLERICAL FORCE.

I deem it my duty to invite your attention to the evils resulting from an inadequate clerical force in this office. This has been reported in previous years, and the Secretary of War has directed that an estimate be submitted to Congress for a sufficient clerical force. This has been done, but the necessary appropriation has not been granted. An estimate for this purpose has again been included in my estimates for this year.

This estimate includes the one fourth and two first class clerks which were taken from the force of this office by the legislative, executive, and judicial appropriation act of July 31, 1894. Two additional clerks of class 2 are also asked for, and this force of five clerks in addition to the allowance for the present fiscal year will be needed to bring up the work of the office which is behind, and to keep up the steadily increasing business devolved upon this office.

APPROPRIATIONS FOR ARMING AND EQUIPPING THE MILITIA OF THE UNITED STATES.

The Department has filled requisitions made upon it during the year for arming and equipping the militia as far as the portion of the limited appropriation for this purpose allotted to the Ordnance Department would permit. The frequent and urgent demands which could not be filled for additional supplies, especially for improved arms and equipments, have reenforced what has been said in my previous reports in regard to the insufficiency of this appropriation, and has emphasized what has been said in regard to making better provision for the equipment of this valuable part of our military service.

There is an urgent demand from most of the States to have their arms changed for a later and better model. The efficiency of the national guard in actual service demands this, and the present appropriation renders it impossible to effect the change of more than a small percentage of the arms each year.

I would also invite attention to what has been said in my two last annual reports in regard to the necessity for some provision of law under which the States may turn in obsolete and unserviceable ordnance and ordnance stores, and obtain credits of the actual value of such stores turned in on their annual allotment of the appropriation for arming and equipping the milita. Correspondence and urgent applications from the adjutant-generals of States and officers of the national guard during the year have enforced the necessity of some provision of law to properly and justly regulate this matter.

WATERTOWN ARSENAL.

The gun-carriage plant has been enlarged and improved by the alteration of old shops, the erection of new shops, and by the installment of new machinery suitable for carrying on economically and effectively

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the work on gun carriages. For several years carriages have been altered for the 15-inch gun and the 8-inch converted rifles. These guns are muzzle loaders and are required for use at certain emplacements where, owing either to the narrow or shallow channels, more powerful guns are not required. The restricted sea way in such channels prevents the passage of a number of vessels at any one time and the simplicity of muzzle-loading guns is such that they can be installed and left with but little care. There are channels in the United States where the mere presence of guns of this nature would prevent an attempt at passage, yet which would lead to the vital parts of important cities. The Rigolets and Chef Menteur channels leading into Lake Pontchartrain may be cited as instances.

Carriages for modern guns are made at this arsenal, and there have been already constructed 12-inch gun lift and nondisappearing carriages, and 8-inch nondisappearing carriages, while there are at present being built barbette carriages for 10-inch guns, and estimates have been made for disappearing carriages for 10-inch guns.

Cast-iron projectiles for the field, siege, and seacoast services, with the exception of shrapnel, are also made at this arsenal, and as the results are constantly checked by the testing machine installed some years since, the material produced is of a high and uniform quality. The arsenal is now equipped for producing large castings such as the platform plates used for mounting guns at the proving ground at Sandy Hook, and for other special massive castings requiring high tensile strength.

As an adjunct to the plant about one-half mile of railroad is required to connect the carriage shops with the dock on the Charles River, that these carriages may be shipped to fortifications by water. The parts of some carriages are of such magnitude that they can not be carried on the railways of the country, and in nearly all cases water transportation is much cheaper than carriage by rail. An estimate for this railroad is submitted.

The testing department, which embraces now a well-equipped chemical laboratory, is in full operation, and, in addition to the usual tests of material for gun and carriage construction and those for private parties in the development of economical engineering and metallurgical construction, work has been done for other departments, such as chains, shackles, and swivels for the Navy Department and shot lines for the Life-Saving Service.

Among the most interesting of the investigation tests continued during the year has been the continuation of experiments on loaded rotating shafts, that is, shafts so loaded as to bend them and introduce alternating stresses within the elastic limit. Reports of these tests are by law published in a special report each year, but this report is not printed until so late a date that the following interesting remarks of

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the commanding officer of the arsenal on this subject are introduced here, viz:

Tests have been continued to determine the endurance of metals to repeated stresses in the form of rotating shafts, and specimen tests have been made in the metal after a large number of repeated loads have been received. Much interest is taken in these tests, as well as in the direct practical determination of the stresses which are endured by material in actual service, because classes of tests form, as it were, a connecting link between the everyday use of metals and the more comprehensive but somewhat abstract investigations of the laboratory.

About the close of the last fiscal year some phenomenal results were obtained with shafts rotated at temperatures above 400° F., when it was found that the metal endured from four to ten times the number of loads which it was capable of enduring when the metal was cold. Specimens of an annular form have been tested from these shafts which ran so long at a blue heat, and the tensile strength was found much higher than that possessed by specimens taken from the cold metal. The general drift of evidence furnished by ruptured specimens has for a long time tended to show that metals while loaded within a limit represented by what is commonly known as the elastic limit would endure a large number of repeated loadings before rupture, nevertheless that when rupture took place, although nominally under a stress not far from the elastic limit, yet there were strong reasons for believing that actually the stresses on the parts ruptured first passed through a state of resistance bearing some relation to the tensile strength of the metal; in other words, that while the elastic limit in a measure fixed the limit of stress which it would be safe to apply a large number of times, yet before rupture would occur the metal would first pass through the higher stresses between the elastic limit and the tensile strength of the metal.

At a blue heat the elastic limit is lower than at atmospheric temperatures, yet the tensile strength is much greater at this elevated temperature. The fact that certain of the specimens from the shafts showed higher final strength is strong evidence that when rupture occurs the metal is then at its maximum strength, or has been at some time prior to the instant of rupture. This being the case, we should expect the development of internal strains might explain the difference between the apparent and the real strength of the metal.

A drop testing machine has been estimated for, and experiments will be undertaken with it to estimate the strength of couplers, a subject of great importance to the railroad companies of the country.

WATERVLIET ARSENAL.

The installation of the plant required for the manufacture of 8, 10, and 12 inch guns is completed, and contracts have been made for obtaining the tools for manufacturing guns of 16-inch caliber. The output of seacoast guns of regulation pattern during the past fiscal year was eleven 8-inch, eleven 10-inch, and six 12-inch. In addition, one 10-inch wire-wound Crozier gun has been completed and work is in progress on seven 12-inch mortars. With the additional machinery already installed the output per annum will be, as anticipated, twelve 8-inch, fifteen 10-inch, and fifteen 12-inch guns.

In addition to the plant for seacoast guns, there is machinery for the fabrication of guns for the field and siege services.

About twenty-five field guns, ten 5-inch siege guns, and ten 7-inch siege howitzers can be produced annually, or, if all the machinery is

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devoted exclusively to the purpose, fifty field guns can be made in the same time.

Now that the plant is fully installed a more thorough system can be and has been introduced in the work, effecting diminution in time and cost and allowing much greater accuracy in the mechanism. A portable scale of 300,000 pounds capacity has been introduced for weighing guns. It is mounted on broad-faced wheels so that it can be transported from one part of the shop to another.

The increased length of the 12-inch guns has made an extension of the shrinkage furnace necessary, and the method of heating used, although very simple, has been found entirely effective.

The above plant is now running in a very satisfactory manner. Constant efforts, however, are being made to perfect the details of fabrication and to diminish the cost. The shops are lighted by electricity, and all the cranes, five in number, are operated by electricity except the two of 30 tons capacity originally installed.

An antiquated water-power plant is being replaced by one of modern manufacture, by means of which about 120 to 130 horse power will be realized as against 35-horse power obtained with the old system. The water power is furnished free by the State of New York from the Erie Canal. A portion of the new plant will be utilized for obtaining electrical energy for use in the gun shop, and will effect, it is believed, a saving of about one-third in the fuel now consumed at that shop, with consequent reduction in the cost of guns.

A new iron bridge has been constructed over the Erie Canal to replace the old wooden structure built many years ago, which had become too weak for the heavy loads now required at the gun factory and which required a considerable outlay in repairs.

Owing to the establishment of the gun factory at Watervliet Arsenal the fire defense available has become entirely inadequate. Not only are the buildings to be taken care of much more extensive, but they and their contained machinery and materials are so valuable that a suitable system, mainly for the prevention, but also for the extinguishing of fires, has become of paramount importance. Estimates for such a system are submitted, amounting to $11,919.75. The destruction of a very small number of the machines in the gun shop would exceed greatly this sum, and a system but partially effective would be of little more use than the one now existing.

An estimate of $98,840 is submitted for the purchase of a tract of land in the vicinity of the arsenal for railroad connection therewith for the erection of a firing house, butts, building of carriages, and complete installment for proving guns. All guns must be proved before issue to the service, as in that way only minor defects, which are sometimes found to exist after the most careful inspection, can be detected. At present it is necessary to send all large guns to the Sandy Hook Proving Ground for proof. The transportation is expensive and the delay

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considerable. Moreover, this proving, which is hardly a legitimate work for Sandy Hook, very materially interferes with the important work which must be done exclusively at that station.

The necessity of proving some thirty-seven large guns annually with mortars and carriages obstructs progress in important experimental work which suffers delay.

It is believed that the outlay on a ground at Watervliet Arsenal would be saved in a very few years. In addition, it is most important that firing to test mechanism should take place in the presence of officers on duty at the gun factory and in proximity to the workshop itself, so that defects may be rendered apparent to those conducting the work and may be remedied without returning the gun over a long distance. This, at present, has to be done in order that slight changes may be made, which changes have at times to be tried by subjecting the gun again to experimental firing.

SANDY HOOK PROVING GROUND.

Daily firings have taken place at the proving ground, Sundays excepted, whenever the weather and other circumstances would permit. All guns, except field guns, and such carriages as require proof, are proved here. Reception tests for armor-piercing shot and deck-piercing shell are made. The continued firings for test of type guns and carriages and all firing with experimental cannon and for ballistic purposes are carried on. A small but well-equipped machine and carpenter shop is provided for use in repairs and in working into shape materials for butts, targets, armor-plate backing, shelters, screens, and all the paraphernalia required for testing.

The tracks which were the property of the Central Railroad of New Jersey, and which remained when that company was directed to cease the use of the grounds at Sandy Hook, were purchased and connect the proving ground with the railroad systems of the country. The transportation from the gun factory to the proving ground, formerly by water routes, is made with much greater dispatch and greatly diminished cost over the railroad. The guns and carriages no longer have to be transported from the wharf after their arrival, but are carried direct to the powerful crane installed in front of the batteries and are unloaded there. The narrow neck connecting the proving ground with the mainland near Seabright is at times cut through during heavy storms, and in such cases expensive repairs have to be made, but notwithstanding this it is estimated that in transportation alone an annual saving of at least $25,000 has been effected during the fiscal year.

An item of $18,500 has been embodied in my annual estimates to cover the expense of placing on piling 2,000 feet of this railroad track where it runs along the narrow neck connecting the reservation with the mainland of New Jersey and for permanent and substantial repairs of the railroad generally.

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An explosive chamber for experiments with fragmentation of shell and the effects of high explosives has been erected.

A search light with appliances for working it has been installed with a view to ascertaining by direct experiment its value as an adjunct to coast defense.

Some idea of the amount of work done at the proving ground can be formed from a statement of the rounds fired during the year, which were as follows:

Rapid-fire guns	2,484
Field and siege guns	703
Breech-loading rifled mortars	378
Seacoast guns	459
Brown segmental gun	176
Total	4,200

The demands upon the force at or connected with Sandy Hook are always great, and any delay at this point almost necessarily occasions delay at the other ordnance establishments. Everything should be done to facilitate the performance of work there.

ROCK ISLAND ARSENAL.

The plant for the manufacture of field and siege artillery carriages inaugurated two years since at this arsenal is now in active operation. It is organized for the construction of:

(1) Machine-gun carriages.

(2) Field-gun carriages, steel, for 3.2-inch B. L. field gun.

(3) Limbers, caissons, battery wagons, and forges for 3.2-inch B. L. field guns.

(4) Carriages and limbers for 5-inch B. L. siege guns and 7-inch B. L. howitzers.

A conservative course has been pursued in making the additions and in improving the plants for the fabrication of the various stores required for the equipment of the infantry, cavalry, and artillery services which are largely supplied from this arsenal.

The best use has been made of existing plants and the small means available for additional machinery with a view to the general effectiveness of the establishment as a whole, but more machinery is needed and should be added for more economical work when means permit.

The power houses and plants for pumping water from the water pool and the rapids of the river north of the island to the reservoirs and for direct pressure for fire purposes have been repaired.

A 16-inch pipe has been laid in the bottom of the river to a point in the rapids beyond the lower extremity of Papoose Island and connected with the pump-house at the shore end so as to be below the action of frost and readily accessible at the valve connection and to permit the use of the reservoir head to flush the pipe. An electric lighting plant for the shops and office, to be extended eventually to the avenues and

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quarters, has been put in; and the shops, office, barracks, and quarters, etc., connected by telephone.

Estimates are submitted for this arsenal for the ensuing year for needed machinery for the shops, and the laying of pavements in shops E, F, and C; for paving Armstrong avenue (in part); and for a brick hospital building and stables.

SPRINGFIELD ARMORY.

The work of manufacture of the new magazine rifle has been almost completely transferred to the new shops at the armory, the transfer of the machinery from the old to the new shops having been made during the year in the most convenient manner. The annealing and tempering room of the new shop alone remains to be occupied, the principal fittings being in place, and it will be shortly put in operation.

The fitting up of the new blacksmith shop is in progress.

These shops will be lighted by electricity, the lighting wires having been laid throughout the shops and the dynamos are about to be placed in the engine-room.

A very complete system of exhaust pipes with fans has been arranged to remove the refuse from the workshops. One system of pipes leads from the stocking and carpenter shops, and carries the shavings, wood chips, and dust to a receptacle convenient to the boiler room from which the refuse is taken to be burned under the boilers. This fan requires 35-horse power for operation. Another system connects the polishing and filing shops, through a discharge pipe, to a tank of water on the outside of the building, into which the emery is driven. A small exhaust fan and pipes have been placed also in the browning room for the benefit of the wheels used there. In other respects the arrangement of the new shops has been made as complete as possible with modern conveniences.

One of the two sets of new quarters for officers which was commenced in September last will be completed by November of this year. The second set of quarters was commenced in the latter part of June of this year, and is now being covered in and roofed.

Since the last report the alterations to and fitting up of machines in the manufacture of fixtures, tools, and gauges for the manufacture of the magazine rifle have progressed steadily. A reorganization of the system in vogue was believed very desirable, if not necessary, in order to perfect the work and keep down the cost, and some radical changes, and it is hoped improvements, have been made, including the introduction of cheaper labor wherever possible and the substitution, as far as practicable, of machine for hand labor. To accomplish this it became necessary to make a number of changes in the personnel of foremen and workmen. Changes in the fixtures and tools and in the order of finishing the parts of the rifle are still being made almost daily and cheaper labor substituted wherever it is deemed practicable.

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No tests have been made during the year of any new inventions in magazine arms under the current instructions to the commanding officer of the Springfield Armory to test and report upon all such inventions as may be presented to him for trial.

FRANKFORD ARSENAL.

The estimates submitted last year for the transfer of the cartridge plant at this arsenal to the now vacant rolling-mill building are again renewed. The following remarks from the last annual report are quoted as showing the necessity for this:

> The development of our modern war material has added so much to the importance of the work at this arsenal and to the demands upon its resources that the occupancy of more shoproom than the buildings now in use contain or afford, is rendered obligatory. A new building is not required, since one built originally for a rolling mill, but not equipped with machinery, is available and well suited for the purpose. The various operations in the manufacture of small-arm cartridges are at present of necessity conducted in four different detached buildings, not suited by reason of location and size for the most economical work on even the present output of cartridges. These buildings are, besides, overcrowded with recent additions of plant required for the manufacture of new model gun sights, fuses, and cartridge cases of large size, or fixed ammunition for mountain and field artillery. With the transfer of the principal plant to the now empty building, space will be afforded under one roof for convenient arrangement of all the successive operations, and facilities given for an expansion from the present maximum output of 36,000 cartridges per day to 250,000 to meet an emergency. There is urgent need for the appropriations required to carry out this rearrangement of the plant.

Further delay in carrying out this needed improvement will work to great disadvantage for the Government. The transition from manufacture of .45 to .30-caliber ammunition, requiring new processes and in many cases new machinery, must, as an alternative, be established as completely as circumstances will admit in the inadequate building space now used for all purposes of manufacture at the arsenal.

The plant for the production of the new ammunition has been gradually developed during the year and the present output, in connection with other cartridge work, is at the rate of 8,000 .30-caliber cartridges per day. The manufacture of .45-caliber ammunition in reduced quantity is continued and it will be necessary to retain machinery specially fitted for this work for years to come. During the past year there were manufactured about 212,000 rifle ball cartridges, caliber .30; 2,537,000 ball and blank cartridges for rifle and carbine, caliber .45; and 2,750,000 ball and blank cartridges for revolvers, caliber .38. The manufacture of fuses for shell and shrapnel, of shrapnel for field guns, gun sights, and kindred miscellaneous articles has also been continued to the extent of existing facilities.

Chemical laboratory.—The work of this establishment has been much extended and systemized for the examination of powders and explosives, some details of which, based upon the appended report of the officer in charge, are referred to in this report under the head of smokeless

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powder. The utility of this laboratory has already been well demonstrated, and, as now managed, it promises to become indispensable to the Department.

BENICIA ARSENAL.

The facilities for making ballistic tests of powders manufactured on the Pacific coast have been increased so that powders for small arms and field guns can be conveniently tried, but they will have to be improved that powder for the heavier guns can be also tested. At present recourse is had to such guns as are mounted in the works in San Francisco Harbor.

The powder tests have included lots of black powder delivered under contract by the California Powder Works for the .45-caliber Springfield rifle, I.K. and sphero-hexagonal powders for the 3. 2-inch B.L. field gun, and hexagonal powder for 15-inch smooth-bore cannon, besides some trials of smokeless powders for small arms and cannon of samples submitted by manufacturers on the Pacific coast.

In pursuance of instructions from this office a circular letter was sent to known manufacturers or inventors of powders and projectiles informing them of the desire of the Department to assist in every way practicable in the development of powders and explosives, that facilities for testing would be afforded at the arsenal, and that when practicable an officer of the post would be present at private tests. Some Peyton powder for the .30-caliber magazine rifle was procured from the California Powder Works. This company has been the first to succeed in the manufacture of small caliber rifle smokeless powder in quantity for the War Department in this country and is now engaged in delivering the powder used in making the .30-caliber magazine rifle ammunition at the Frankford Arsenal. Favorable results were obtained with small samples of smokeless powder for the .30-caliber magazine rifle, furnished by the Giant Powder Company of California. The United States Smokeless Powder Company, of San Francisco, also furnished samples of smokeless powder for the .30-caliber rifle and for field guns, which have been tested without as yet developing very favorable results.

Tests were made with the Reed bullet in which the jacket is deposited on the lead core by electrolysis. No advantage, however, seems to exist over the ordinary mechanical method of applying the covering to the lead.

The estimates submitted for this arsenal for the next year comprise small fireproof boiler houses for the new shops and the pump house to replace extemporized and worn wooden buildings; also to renew dilapidated wooden fencing around part of the grounds, and to place iron fencing on the side now open along the line of railroad.

The probability that military exigencies may at any time suddenly require considerable manufactures of military supplies always exists, and the maintenance of the arsenal in condition for active operations is consequent duty.

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MACHINE GUNS.

The contract for 18 of the new caliber .30 10-barrel Gatling guns, to which reference was made in the last annual report, has been completed.

In the proof of these guns with the new smokeless powder ammunition trouble was experienced from the escape of gas through punctured primers, which threw the extractor out of place and temporarily disabled the gun. This was remedied by providing vents for the escape of gas in such cases without injury to the gun. Reports have been received of occasional failures of the new feed strip for this gun. The company claims these failures were due to imperfections in their manufacture. As a result of this a careful inspection of the feed strips furnished by the company to the Department has been instituted.

Tests of a 2-barrel machine gun, invented by G. W. Robertson, have been made at the Springfield Armory with as yet no conclusive results. The gun, as originally tried, was fitted with .45-caliber barrels. The tests already made have been unsatisfactory, chiefly on account of the mount, which failed to hold the gun properly, resulting in inaccurate shooting. It was also considered too heavy for any military service to which the gun might be adapted. A light, self-supporting tripod mount, intended to adapt the gun for easy carriage on pack animals, has been prepared by the inventor. The gun with this mount and fitted with barrels of .30 caliber will be given a further trial.

A 2-barrel Gardner machine gun of .303 caliber, with ammunition, was imported by the English makers, and at their request a trial was undertaken by the Department at the Springfield Armory. Owing to defects in the ammunition the trial was suspended and the gun withdrawn by the company for other uses.

MAGAZINE RIFLE, MODEL 1892, CALIBER .30.

The first of these arms was completed at the Springfield Armory about the 1st of January last. By June 1, the output had been increased to the rate of 40 rifles per day. At this date 60 rifles per day are being produced and in a few months it is expected to advance to the rate of 80 rifles per day.

Up to September 28, 2,950 of the new magazine rifles had been manufactured. Early issues of single rifles were made to the military headquarters, the governors of States, and to the military service schools, besides a special issue of 40 rifles to Fort Sheridan, Ill., and issues will now be made to the regiments in the regular service. Several causes of delay in the issues to the Army have occurred.

A sufficient number of bayonet scabbards had not been made and changes were found necessary in the sights and ramrods, and finally when it was believed that the arms were ready for issue it was found that rust had appeared in the chamber. All of these difficulties have been remedied, and as sufficient scabbards will soon be completed

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there should be no further delay in issuing the arms as fabricated. Experience has not yet developed all the difficulties that may have to be considered with smokeless powder. The formation of rust in the chamber and about the striker when gas escapes through the primer must be provided for. Soda water is now being used instead of sperm oil for removing the powder residue, after which the bore is coated with cosmoline before the arm is packed.

No erosion, so far produced in the face of the bolt, has been found to render that part unserviceable. To enable this surface to better resist erosive action, when the bolt is casehardened, a small piece of potassium cyanide is placed in the well and thus the hardness of the front surface is increased.

Some of the rifles that have been issued did not embody the latest changes in the sights. Complaints have been received that the sights were not graduated for range shooting, or arranged to compensate for drift, and besides have no wind gauge. Opportunity will be taken to exchange the small number of sights having any defects which have been already sent out for those in which the sight has been corrected by later experiments at the armory. The sight notches on the leaf and slide are placed to the left of the axis of the bore, making absolute correction for drift at 500 and 1,000 yards and approximate correction at other ranges. The rear sight, for reasons explained in the last annual report, is not provided with a wind gauge.

Bayonet scabbard.—The pattern of bayonet scabbard previously adopted is a body of steel with mouthpiece and two springs between which the bayonet is held; an open hook of steel riveted to a boss on the body serves to attach the scabbard to the belt. On account of the weight of this scabbard, 7½ ounces, repeated trials have been made and are still in progress to produce a scabbard made of aluminum. Samples of sheet aluminum, alloyed with other metals to obtain stiffness, were successfully formed with the same machines as are employed in the manufacture of the steel scabbard, but all methods tried to produce a firm, neat, and practicable union of the folded edges have failed. Numerous solders exist which can be used on this metal by means of the ordinary soldering iron, but that method is not suited to this particular work. Another company is now experimenting with the construction of a scabbard with folded edges; this gives a very attractive looking scabbard, but so far one not possessing sufficient stiffness.

Steel for gun barrels.—No difficulty has been met in securing the quantity of steel required for manufacture under the established standard for metal, to have an elastic limit of not less than 60,000 pounds with tenacity of about 100,000 pounds, and elongation of 15 to 20 per cent, the metal to be homogeneous, free from seams or hard spots, and capable of being readily worked by tools.

Steel now in use is furnished by two firms. The qualities slightly

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exceed the requirements mentioned, and the metal has been quite uniform. Continued experiments have been made with samples of steel furnished by other manufacturers. Twenty-two sample lots in all, furnished by different manufacturers, or different qualities from the same manufacturer, have been tried. Many of them show considerably higher physical qualities than the standard metal, but have been found to work with difficulty or to be unsuited for use from various causes. Two samples of these, however, have been selected from which to make barrels for proof tests. One contains, it is understood, about 4 per cent of nickel. The tests show an elastic limit of 70,000 pounds and a tenacity of about 106,000 pounds, and 21 per cent elongation. The other is a lot of ten barrels of Swedish steel. The tests of this metal show 80,000 pounds elastic limit, tenacity of about 113,000 pounds, and elongation of 14 per cent.

The report of the principal operations, by the commanding officer of the Springfield Armory, is appended:

SMALL CALIBER RIFLE AMMUNITION.

The regular manufacture of service ball cartridge ammunition for the .30-caliber magazine rifle, model 1892, using a smokeless powder of domestic production (Peyton), was commenced at the Frankford Arsenal in May last, and up to the end of June about 200,000 rounds had been made and issued or placed in store. A quantity of this ammunition previously made for use by the different magazine gun boards, and for the extended experiments required in developing the ammunition and in the proof of rifles at the Springfield Armory, was charged with the several varieties of foreign powder, Wetteren and Troisdorf, procured in small lots before the receipt of the domestic powder now being used.

The output of .30-caliber rifle ball cartridges is now at the rate of 8,000 per day, which will be increased in proportion as the manufacture of the .45-caliber Springfield rifle ammunition can be discontinued and the needed changes of machinery and plant are made. The following data relate to the .30-caliber cartridge, charged with Peyton powder:

Cartridge complete, bottle-shaped; weight 412 grains, length 3.08 inches.

Projectile, cylindro-conical shape with ogival head and flat base; weight 220 grains, length 1.265 inches, sectional density 0.33; jacket material, cupro-nickeled steel; filling material, hardened lead 12.5 parts tin and 87.5 parts lead.

Shell, weight 150 grains, length 2.315 inches; material, cartridge brass, tinned.

Charge, for initial velocity of 2,000 feet per second, 43 grains powder (Peyton); average gas pressure, 33,000 pounds per square inch.

The blank and gallery practice cartridges adopted for the 30-caliber magazine rifle are briefly described, as follows:

The blank cartridge is adapted for loading through the magazine. For this purpose the case is made of the ordinary cartridge brass, hollow throughout, and has the outward form of the ball cartridge entire,

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including the bullet. This is necessary in order that the feed mechanism may operate properly. The cartridge is sufficiently firm to endure the working of the magazine and repeated use without injury. The point is divided into three parts by open cuts, which are brought together and formed into the shape of the ordinary projectile after the loading charge has been inserted. There are no wads, or other substance than powder, used in the charge. The case is sealed by coating the end with collodion varnish.

When the cartridge is fired the point is opened under the pressure of the gas. The obturation is good. The cartridge can be readily extracted and can be used for reloading. As it is found that the fouling from black powder used in these cartridges can be removed from the bore without difficulty, the .30-caliber blank cartridges now being made are charged with black powder. Experiments made in firing with this cartridge against paper screens at a distance reduced to 6 feet showed no perforation larger than would be formed by a single grain of unburned powder. At 20 feet distance no marks were visible on the screen.

The cartridge case for gallery practice is adapted for single loading only. The exterior dimensions of the case are the same as those of the regular cartridge case. It is made from a solid rod of brass and bored to small diameter to receive the reduced charge of black powder and hardened lead ball, leaving a strong, heavy case of sufficient strength in itself to resist the force of discharge without expansion. Samples of these cases have been fired 108 times at Frankford Arsenal without resizing and remained in serviceable condition. Experiment having shown that the round balls, if made with the proportion of tin 1 to 16 of lead, occasion even slightly less fouling than with the proportion of 1 to 10, the former proportion has been adopted.

The comparative tests of .30 caliber lubricated and nonlubricated bullets, referred to in the last annual report, resulted as then stated in finding that lubricant is not required for a bullet with german-silver jacket. During the past year an additional 1,000 rounds has been fired from each of the rifles N and O, making about 3,000 rounds in all from each, and using nonlubricated bullets with jackets of german silver and of cupro-nickeled steel, contemporaneous experiments having shown the superiority of the latter metal for bullet covering as regards penetration and resistance to deformation. This last series of the tests resulted favorably for the steel covering, as it was shown that there was no very appreciable falling off in either the velocity or accuracy of the rifles after 3,000 rounds, and the rifle using the cupro-nickeled steel jacket seems to have held its own a little better than the other. Condensed reports of the series of experiments with these rifles are appended.

During these tests the fact was elicited that with the .30 caliber rifle fired from a fixed rest, as is necessarily done in such cases, the accuracy of fire was materially affected by vibrations of the barrel, and it was

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decided to use one of the heavy .30 calibre pressure barrels, having the same dimensions of bore as the rifle, for additional comparative tests of the german silver and cupro-nickeled steel bullet coverings. The results are given in the appended report, dated at the Frankfort Arsenal, December 2, 1893. The velocity with the cupro-nickeled steel jacket was uniformly superior, and the mean variations were much in favor of this jacket. The record for accuracy also favors the steel covering.

A comparison of the accuracy of the rifle and the heavy pressure barrel, both fired from fixed rest, is shown by the following. The record is for consolidated targets of 10 shots each, and comprises 35 targets for the heavy barrel and 50 targets for the rifle with the ordinary barrel, at a range of 500 yards:

	Circle of shots radius.	Mean vertical deviation.
Heavy barrel:	*Feet.*	*Feet.*
Lubricated ammunition	0.358	0.260
Nonlubricated ammunition	0.381	0.270
Rifle O, lubricated ammunition	1.18	1.04
Rifle N, nonlubricated ammunition	1.06	0.84

The cupro-nickeled steel is made in sheets, from which the jacket or covering for the hardened lead filling of the bullet is drawn, in about the same way as the cartridge case is made. The sheet metal is rolled from plates of steel, overlaid on each side by the metal alloy of copper and nickel. The material is an imported product, controlled by a single firm, and is, moreover, objectionable on account of cost. Very promising results have recently been obtained with a sample of cupro-nickel alone of domestic manufacture. As a rule this metal, although of greater first cost, is easier to work than that containing the steel, does not require the labor and expense of annealing, and gives a finished bullet somewhat superior in appearance, and its scrap is valuable, whilst that from the other metal is worthless. Experiments will be continued with jacket metals and effort made to find some suitable material of domestic production and reduced cost.

The production of a suitable primer for the .30 caliber cartridge using smokeless powder has been proven a continued source of difficulty, involving the mixture as well as the quantity of the fulminate required to properly ignite different varieties of powder. Smokeless powders are, as a rule, more difficult to ignite than the black, and practice has led to a considerable increase in the quantity of fulminate composition over that used in the .45 caliber ammunition. The force of its explosion is correspondingly increased, and causes much trouble in making a cup that will not be pierced by the firing pin or ruptured and allow the escape of gas into the breech mechanism. Such an escape of gas into the breech mechanism produces a serious effect upon the face of the bolt by pitting and scoring the surface. Experiments show that dif-

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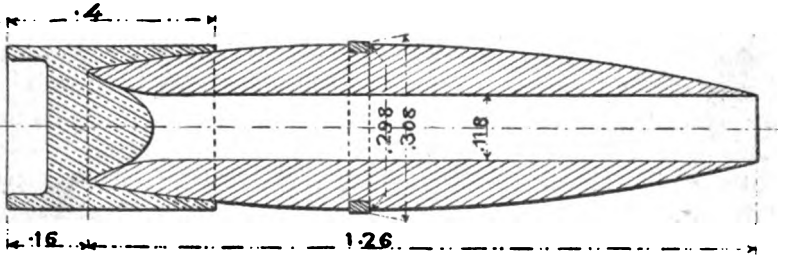
ferent primers are required for the proper ignition of different varieties of powder, even when a perceptible hang-fire is not produced, and the quantity of primer composition or strength of the primer may cause a marked variation in velocity with identical charges of the same powder. Thus, with a charge of 36 grains of Wetteren powder, the mean velocity for 20 rounds, using 0.25 grain pellet, was 1894 feet per second, as compared with a velocity of 2,010 feet per second using 0.50 grain pellet of fulminate composition.

The machine-gun trials of the past year with smokeless powder ammunition have directed special attention to the inconvenience as well as the danger attendant upon hang-fires which have been not infrequent. The rapid withdrawal of the fired cartridge from these guns renders the question of the primer one of the most important ones now pending in regard to the use of smokeless powders in machine guns.

By making a slight change in the head space of the rifle in connection with variations in the primer manufacture, the primers now made by the Department are fairly satisfactory for the .30-caliber rifle, but the matter of primers for smokeless powder ammunition for the service is still in the experimental stage. It will continue to be actively investigated until a satisfactory conclusion is reached.

Hebler tubular bullets.—Through the courtesy of Prof. W. Hebler, Kussnacht, Switzerland, the Department has recently been enabled to conduct some very interesting experiments with the Hebler tubular bullet adapted to the .30-caliber magazine rifle. Reports of these experiments at the Frankford Arsenal by Lieut. Col. Farley, and of certain computed trajectories for the service, and tubular bullets by Lieut. C. L'H. Ruggles, are appended. The experiments embrace a number of projectiles of different forms and construction, but reference need be made here only to one form of the tubular bullet which was made pursuant to Prof. Hebler's suggestions, and shown in the following figure (tubular bullet):

Tubular bullet (about 3 times enlarged).



The bullet weighs 104 grains and is made entirely of steel, except the narrow, copper, rotating band around the middle. The sabot, on the rear end, is made of vulcanized fiber, weighing only a few grains; its only purpose is to seal the escape of gas and it falls away from the projectile after leaving the muzzle of the gun. Prof. Hebler estimated that

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with a bullet of this form and construction the initial velocity to be obtained in the .30-caliber rifle would be about 3,000 feet per second, with a pressure of about 40,000 pounds per square inch, provided perfect combustion of the powder be secured by using a powder of properly regulated size of grain. The results actually obtained in these respects were secured by using the most available smokeless powder at hand, viz, an initial velocity of over 3,100 feet per second with a pressure of about 46,000 pounds per square inch, using a charge of 42 grains of Leonard J powder.

The first experiments were conducted in March, 1894. The firings were made from the heavy .30-caliber pressure barrel in a fixed rest, using Wetteren (1891) powder with the service bullet, and Leonard J powder with the tubular bullet. The results for velocity and accuracy at 500 yards are herewith:

	Service bullet.	Tubular bullet.
Weight of bullet.....grains..	220	104
Weight of powder charge.....do....	37	42
Pressure per square inch.....pounds..	38,500	46,000
Velocity, instrumental (53 feet from muzzle):		
Number of shots.....	10	4
Greatest.....feet per second..	2,060	3,058
Least.....do....	1,970	2,901
Mean.....do....	2,028	3,006
Accuracy (target 1,491 feet):		
Number of shots.....	30	10
Rad. circle of shots.....feet..	0.353	1.31
Vertical height from center of impact to axis of bore, prolonged.....do...	14.036	7.05

The results deduced from this series of experiments applying Ingall's formulæ, by tentative processes, for the ballistic coefficient of the tubular bullet and the remaining velocities at different ranges, etc., were such as to lead to supplementary trials in June, 1894, wherein the remaining velocities of the bullets, at a range of 1,450 feet, were actually measured, thus affording the most accurate means of determining the ballistic coefficient and other data necessary to solve the trajectory of the bullet.

In these trials, unfortunately, out of 7 shots for velocities with the tubular bullet the remaining velocity for one only at 1,450 feet was obtained, the six others being lost. But the deductions from this record are so well sustained by other data as to make it available at least for all practical purposes. The following table contains observed and deduced data from the June experiments, together with that computed for the trajectories of the two bullets for muzzle velocities assumed, viz, 2,000 feet per second for the service and 3,000 feet per second for the tubular bullet:

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	Service bullet.	Tubular bullet.
Observed velocities, mean:		
Number of shots	3	7
At 50 feet from muzzle, feet per second	1,983	3,054
At 1,450 feet from muzzle, do	1,172	1,685
Observed accuracy, 1,491 feet:		
Number of shots	18	18
Radius of circle of shots, feet	0.75	2.10
Vertical height, center of impact to axis of bore prolonged, corrected, feet	13.96	6.80
Deduced:		
Value of coefficient of reduction, e	0.88583	0.55491
Value of ballistic coefficient, C	0.374	0.32988
Muzzle velocity, feet per second	2,021	3,108
Remaining velocities at ranges of—		
1,641 feet (500 meters), do	1,101	1,556
3,282 feet (1,000 meters), do	799	904
4,920 feet (1,500 meters), do	617	685
6,561 feet (2,000 meters), do	476	495
8,202 feet (2,500 meters), do	368	364
Projectile energy at—		
Muzzle, foot pounds	1,996	2,331
1,500 feet, do	650	603
Computed trajectories:		
Assumed muzzle velocities, feet per second	2,000	3,000
Weight of bullet, grains	220	104
Diameter of bullet ($\sqrt{D^2-d^2}$ for tubular), inches	.308	.28489
Sectional density	.3313	.18306
Range for maximum ordinate of 5.9 feet, yards	565	722
Range for maximum ordinate of 8 feet, do	639	800

Range trajectories.	Angle of projection.	Angle of fall.	Maximum ordinate.	Remaining velocities.
	° ′ ″	° ′ ″	*Feet.*	*Ft. sec.*
500 yards:				
Service bullet	0 31 30	0 45 41	4.15	1,142
Tubular bullet	0 15 22	0 22 16	1.93	1,580
1,000 yards:				
Service bullet	1 35 36	2 44 49	28.54	883
Tubular bullet	0 52 33	1 50 30	16.89	940
1,500 yards:				
Service bullet	3 18 00	6 09 10	93.07	657
Tubular bullet	2 08 00	4 51 21	67.33	708

The total weight of tubular bullet cartridge is 296 grains, and of the service cartridge 412 grains, making the weight of 100 of each about 4.25 and 5.9 pounds respectively.

The estimated energy of free recoil for the .30-caliber magazine rifle firing the two bullets is, for the tubular 6.73 foot-pounds, and for the service bullet 11.35 foot-pounds.

Fired into well-seasoned oak, across the grain, at a range of 3 feet, the penetrations are 7 inches for the tubular and 16.5 for the service bullet. This, it appears, must be chiefly attributed to deformation and great deflection of the light bullet in penetrating the hard oak with very high velocity.

The tubular bullet is at a marked disadvantage as compared with the service bullet with respect to accuracy; the trials are too limited, however, to draw a definite conclusion on this point. But, contrary to anticipation, as derived from reports of trials made elsewhere, it is also found to suffer greater retardation from the air than the service bullet, since the velocity falls off more rapidly. The velocities of the two bullets become equal at about 2,700 yards. The projectile energies and the penetrative power of the two become equal at about 450 yards; short of this distance the penetration of the tubular bullet should be greater, and at

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longer ranges should be less (with a diminishing ratio) than that of the service bullet.

The light weight of this tubular bullet makes it doubtful if the shock would be sufficient for military use. The advantages which may be claimed for it are: Weight of cartridge, as enabling an increase of about 40 per cent in the number carried per man; and flatness of trajectory, with its accompanying increase of danger space; a material increase of range for the same elevation, or, conversely, a diminished height of rear sight needed to attain useful ranges. And it is probable that, including the important question of powder pressure, these advantages can be secured better with a tubular (quasi sub-caliber) bullet than with a solid bullet of smaller caliber and equal weight, since the powder pressure must be increased as the caliber is diminished.

From this it follows that it would be more desirable to use a tubular bullet of requisite weight for hitting effect, even taking a larger caliber than .30, if found expedient, than to use a smaller caliber with solid bullet, in order to derive equal advantages in flatness of trajectory, etc., range, and weight of ammunition.

RELOADING AMMUNITION FOR TARGET PRACTICE.

It has been decided not to have the new caliber .30 cartridges reloaded by troops for target practice at posts, and instead of this to have empty fired shells returned to the cartridge factory at Frankford Arsenal, to be reloaded there, and to credit the company commanders on their allowance for target practice with the value of all such fired shells returned. The preparation of suitable reloading tools for this small caliber would present unusual, perhaps insurmountable, difficulties.

Further, it is doubtful whether reloading ammunition, with the black powder even, by troops, has proved economical for the service. The objections to the system have been, the cost of reloading tools; much imperfect ammunition; the injury to rifles from sand, grit, and imperfect cartridges; having in the hands of troops two kinds of ammunition, that is, reloading and new; the time consumed by the soldier in reloading, which is required for other duties; and the great difficulty and expense frequently incurred in transporting powder for reloading purposes to the posts. It is estimated that the losses resulting from all these sources are more than equivalent to the expense of returning the empty cases to the cartridge factory for reloading purposes. The expense of returning the reloaded ammunition to troops should certainly be less than the cost of transporting the loose powder, bullets, primers, and the reloading tools. The critical expert inspection and tests of fired cases at the factory before reloading them will make them the same as new ammunition, with the one resulting condition, viz, that the shells of such new ammunition will in no case be used more than once before they are again returned to the factory.

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SMOKELESS POWDER FOR SMALL ARMS.

Contracts were made with the California Powder Works (Peyton), and the Leonard Smokeless Powder Company, of New York, in December last, each for 5,000 pounds of smokeless powder for the .30-caliber magazine rifle. The Peyton powder was delivered in good season, and in August of this year, under the provisions of contract, an additional order for 10,000 pounds of the same powder was placed with that company. The Leonard powder, owing to difficulties encountered in the manufacture to meet the specification of the Department, has not as yet been delivered. With the sources of supply now available, however, the Department is in position to procure needed supplies of smokeless powder of domestic manufacture for ammunition for the new magazine rifle.

About twenty-five varieties of small-arms smokeless powder have been received at the Frankford Arsenal and subjected to various tests, the more important of which are given in the appended reports from that arsenal. The arrangements for testing powder have been well systematized; and whilst further development, particularly in the laboratory tests, is constantly kept in view, each variety of powder can be subjected to tests well suited to determine its utility for the military service, preliminary to the continued test for keeping qualities in actual service.

The ordinary ballistic tests of a powder comprise firings for velocity and pressure, particularly with reference to uniformity. The required muzzle velocity for .30-caliber magazine rifle is 2,000 feet per second, on which is allowed a mean variation of 20 feet per second in twenty consecutive rounds. The maximum pressure, as measured in ten consecutive rounds, is limited to 38,000 pounds per square inch.

In the special tests, samples of the powder before being loaded into cartridge cases for firing are exposed, one freely to the atmosphere, and another first to excessive moisture and afterwards to the atmosphere. Separate samples and lots of loaded cartridges, before firing, are also subjected to heat, to moisture alone, and to cold. The cold exposure comprises four periods of six hours each in a temperature of about —40° F. Under these tests the velocity is allowed to vary 100 feet per second from the standard previously determined, with a mean variation of 30 feet per second, and the limit of maximum pressure is raised to 45,000 pounds.

The stability test, which has been found quite reliable in determining the keeping qualities of smokeless powder so far as present experience indicates, consists in exposing one gram of powder to a temperature of 150° F. in a closed test tube containing a piece of potassium iodide starch paper. The test is considered satisfactory if no discoloration of the paper is shown before at least fifteen minutes exposure. Other tests relate to the corrosive effect of the powder on steel and cartridge metal, the residue left in the bore of the rifle on firing, facil-

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ity of machine loading, and the determination of the specific gravity, gravimetric density, granulation, residue from flashing, temperature of ignition, and heating effect on the rifle barrel during rapid fire.

The heating of the barrel is determined by a maximum thermometer lowered into the bore and suspended by a wire, about the position occupied by the bullet in the loaded cartridge, the breech being closed and the muzzle stopped with a cork. The temperature is taken after 25 rounds fired in about one minute. Firing 25 rounds of Peyton powder in 64.5 seconds increased the temperature of the bore 107° F., or from 89° to 196°.

Tests for the temperature of ignition of Peyton powder gave the following results:

At 285° to 289° F. the substance boiled, but did not explode.

At about 293° F. it exploded after fifty-eight seconds.

At 338° F., after twenty-four seconds.

At 392° F., after fourteen seconds.

All the grains boiled up a few seconds before exploding.

Selecting Peyton and Leonard powders as representatives of the class containing nitroglycerin as an ingredient, and Troisdorf, Wetteren (1893), Walsrode, and Rifleite, all of foreign manufacture, as representative gun-cotton powders, tests were made for sun exposure, for corrosive action when flashed on polished steel plates, and for action of the powder simply laid on plates of cartridge metal and stored in the dark for about nine months.

The sun exposure was continued day and night for a period of fifty-six days during the winter season. The samples were placed in shallow trays with glass bottom, and protected from the weather by means of a sheet of glass. The nitroglycerin powders gave most loss of weight and showed the greatest exudation and change of color and constitution of grain. With the best samples, however, the changes in velocity, stability, and temperature of ignition compared favorably with the nonnitroglycerin or gun-cotton powders. On the other hand the conclusion reached from the corrosive effect shown on steel plates was that when burned in the air the gun-cotton powders had most effect on steel, and this was more noticeable when the flashed residue was allowed to remain for some time undisturbed.

The appended reports from Frankford Arsenal contain the results of tests of samples of Peyton and Leonard powders, submitted in advance of the award of contracts to these companies, and of the Peyton contract powder; also of samples of Troisdorf and of Walsrode powder for the .30-caliber magazine rifle, and samples of Walsrode and Rifleite powder for the .45-caliber Springfield rifle. With regard to the .45-caliber rifle no results have yet been obtained with smokeless powder showing marked superiority over black powder, or such as will warrant the substitution of smokeless for black powder in ammunition for the .45-caliber Springfield rifle.

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Samples of .30-caliber smokeless powder, presented by Albert Smith, of New York, and H. P. Weidig, of Newark, N. J., have been tested without conclusive results. The Weidig powder is claimed to be pure cellulose treated in a peculiar way.

Promising results were obtained with small samples of .30-caliber smokeless powder presented by the Giant Powder Company, of California, and tested at Benicia Arsenal, as shown by the following:

Date.	Powder.		Rounds fired.	Velocity.		Pressure per square inch.
	Designation.	Weight.		Mean.	Variation.	
		Grains.	*No.*	*Ft. sec.*	*Ft. sec.*	*Pounds.*
June 15, 1894	A	45	4	2,145	5.5	39,250
	B	43	2	2,120	0.0	35,750
	AA	37	3	2,084	36.0	41,500

The Giant Company's powder has not been made in quantity or, so far as known, subjected to tests for stability or keeping qualities.

With the shipment of smokeless cannon powder to Philadelphia (July 24, 1893), from the Cologne-Rottweil Powder Works, there was received a lot of 30 kilos invoiced as "Smokeless powder for small-bore rifles, 0.303 caliber," which is presented by the director of the works, Mr. Heidemann. This powder is said to contain no nitroglycerin and is claimed to possess in a remarkable degree the property of not wearing the bore of rifle in firing. Data is presented to show that the accuracy of fire from a German military rifle was not materially lowered after firing 10,000 rounds. Early opportunity will be taken to test the efficiency of this powder in the .3 -caliber magazine rifle, model 1892.

ARMAMENT OF FORTIFICATIONS, ETC.

Cannon powders.

The difficulties and delays experienced in obtaining suitable powders for the test of type-guns and for issue to the service, as noted in my last report, made it expedient to station an ordnance officer at the powder works, who by his technical acquirements would be able to render assistance to the manufacturer in the investigation and development of powders.

Lieut. (now Captain) S. E. Stuart, Ordnance Department, was selected for this duty and sent to the works of the Messrs. Du Pont & Co., near Wilmington, Del., early in the present calendar year.

He is charged not only with the supervision of the manufacture of powders for the service, but is particularly directed to seek to further the development of brown powders for sea-coast guns and smokeless powders for all classes of guns and firearms.

To facilitate the prosecution of his duties the Department furnished him with a 3.2-inch B. L. field gun and an 8-inch B. L. rifle mounted

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on carriages, with an outfit of projectiles and instruments for determining pressures and velocities. The Du Pont Powder Company has on its part provided grounds for proof ranges, with platforms, butts, targets, houses, etc., for the installation of the guns. The 3.2-inch field gun has been now used since last May in making manufacturers' tests of black and smokeless powders. The installation of the 8-inch gun is more recent and is not yet complete, as the chronographs have not as yet been received. Temporary use, however, can be made of instruments belonging to the company and the gun will now be used for testing samples.

The field gun is located at the works and the 8-inch gun at Springfield Station, Pa., on the line of the Wilmington and Northern Railroad Company, about 45 miles from the works. This distance, though a source of inconvenience, will not seriously retard the manufacturing tests which should be made. A nearer location for the firing ground, for a piece of this caliber, was not available.

The great advantage of having an ordnance officer constantly on duty at the powder works, and working in conjunction with the investigations and tests at the new chemical powder laboratory at the Frankford Arsenal, are already so apparent that we are warranted in believing that important improvements in our military powders, which is of paramount importance, may result from this plan. Most of the reports of this officer are more or less confidential in their nature, and can not be quoted from, and are valuable.

Smokeless powders.—Since the date of my last annual report the only tests of smokeless powder, except two rounds with German smokeless powder fired from the 8-inch B. L. rifle, have been made with samples furnished by the Leonard Smokeless Powder Company, with the object of observing the effect produced by changing the proportion of the ingredients and the size and form of the grain.

Some of the more important results obtained with this powder are the following:

5-inch Brown segmental wire-wound gun.

Powder, kind.	Number of rounds.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
		Pounds	*Pounds.*		*Pounds.*	
Leonard smokeless..	1	25	60 $\frac{1}{16}$	2,663	34,707	Red powder. Rods 40 inches long, 0.75 inches diameter. N. C. Ruby.
Do.....	1	30	60 $\frac{1}{16}$	3,128	53,500	
Do.....	1	30	45	3,024	40,170	
Do.....	1	30	62	2,893	49,795	C. A. Containing an excess guncotton. Ruby. Rods 40 inches long, 0.75 inches diameter.
Do.....	1	32	60 $\frac{1}{16}$	3,110	52,934	
Do.....	1	32	61	2,977	48,832	
Do.....	1	30	61 $\frac{1}{16}$	2,701	35,200	Ruby X 7 Exptl., with reduced amount linseed oil.
Do.....	1	34	61	3,015	48,111	
Do.....	1	36	62	3,130	56,043	

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3.2-inch B. L. rifle, Driggs-Schroeder.

Powder, kind.	Number of rounds.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
		Pounds.	*Pounds.*		*Pounds.*	
Leonard smokeless ..	1	$1\frac{5}{16}$	$13\frac{5}{16}$	1,830	18,250	Exptl. powder No. 8; natural color; $\frac{7}{16}$ inch diameter, tubular.
Do.....	1	2	$13\frac{5}{16}$	1,937	24,400	

6-pounder Driggs-Schroeder rapid-fire gun.

Leonard smokeless ..	1	1	6	2,019	Below 9,000	Natural color; cylindrical; 10.25 inches long; 0.36 inches diameter.
Do.....	1	$1\frac{4}{16}$	6	2,243	Below 24,000	
Do.....	1	$1\frac{8}{16}$	6	2,575	33,250	
Do.....	1	$1\frac{8}{16}$	6	2,575	33,492	

The above results, though in some instances quite irregular, show high ballistic qualities. It is understood that the Leonard Powder Company is endeavoring to respond to the demand for a smokeless powder with a reduced proportion of nitroglycerin.

The tests made with the German smokeless powder were for the purpose of determining the effect of long storage in hermetically sealed cases. Two rounds were fired in the 8-inch B. L. rifle as follows:

8-inch B. L. rifle, steel model 1888, Watervliet Arsenal.

Powder, kind.	Number of rounds.	Charge.	Projectile.	Muzzel velocity.	Pressure.	Remarks.
		Pounds.	*Pounds.*		*Pounds.*	
German smokeless	1	45	300	1,965	30,945	Rifle No. 9.
Do	1	46	$302\frac{8}{16}$	2,018	31,770	Rifle No. 11.

The results, compared with those noted in my report for 1889, indicate that this powder, when stored as described, can be kept for a period of nearly three years without material deterioration.

Samples of smokeless powder have been recently received at the Sandy Hook Proving Ground from the Walsrode Smokeless Powder Company, of New York, for field guns, and from the Cologne Rotweill Powder manufacturers for 8 and 12 inch B. L. rifles. These powders have not as yet been tested.

In addition to the steps taken by the Department for the particular development of smokeless powders and explosives on the Pacific coast, by trials made at the Benicia Arsenal, proposals have been invited from this office to procure samples of smokeless powder for field, siege, and sea-coast guns for trial at the Sandy Hook Proving Ground. The specifications are annexed in an appendix to this report. The specifications for 3.2-inch field-gun powder require an initial velocity of 1,450 feet per second with a projectile weighing 16.5 pounds and a pressure not exceeding 30,000 pounds per square inch. The experiments with this powder, now in course, have for their object the selection of a smokeless powder for the service of this gun and, concurrently, to

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determine the suitable capacity of cartridge case for fixed ammunition. The specifications for the larger guns require the following ballistic qualities:

5-inch siege gun: Initial velocity about 1,830 feet per second and pressure not greater than 31,360 pounds per square inch.

7-inch siege howitzer: Initial velocity about 1,085 feet per second and pressure not greater than 26,880 pounds per square inch.

8-inch seacoast gun: Initial velocity not less than 2,000 feet per second and pressure not greater than 33,600 pounds per square inch.

10-inch seacoast gun: Initial velocity not less than 2,025 feet per second and pressure not greater than 33,600 pounds per square inch.

For seacoast guns the highest attainable velocities within allowable limits of pressure and erosion are desired.

For the siege pieces it is not deemed desirable to increase the velocities above the standard for black powder, and improvement in ballistic effects is to be sought principally in the reduction of the weight of powder charge.

In negotiating for these powders the Department has received bids from the California Powder Works, Du Pont de Nemours & Co., the Leonard Smokeless Powder Company, and the Maxim Powder and Torpedo Company. Owing to the limited amount of funds available for the guns of larger caliber, awards have been made only for powder for the 8-inch seacoast gun; and in order that the best competitive results may be obtained, each of the above-named firms has been given an order to furnish sufficient powder for about ten full charges for this caliber of gun.

SEACOAST GUNS.

But little progress has been made during the past year in the test of the type 10-inch and 11-inch B. L. rifles, owing to the failure of the manufacturers to produce brown powder of a suitable quality. The 10-inch B. L. rifle has been fired in all 217 rounds, and the 12-inch rifle 111 rounds to date. It is expected, however, that the tests will be completed during the coming year, as more uniform results are already being obtained with the sample lots of brown powder furnished for the 10-inch gun, and it is hoped that a similar improvement will be made in the brown powder for the 12-inch B. L. rifle.

The 8-inch B. L. rifle manufactured at Watervliet Arsenal has been fired 319 rounds. This gun and the type 10-inch B. L. gun show more or less erosion of the bore and chamber and the rifling is so much worn down at the commencement of the forcing cone, where it is of reduced depth, that the projectile is no longer retained in its original loading position, and the accuracy of fire of this piece, though still good, is not up to the high standard attained when the gun was comparatively new. It is proposed to enlarge slightly the rotating band on the projectile, in order to stop the projectile at its original loading position and restore, if practicable, the accuracy of fire.

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The number of guns manufactured at the Army Gun Factory during the past year has not been as great as the maximum capacity of the gun factory, owing to the limited funds available for manufacture. A number of improvements have been introduced in the processes of manufacture during the past year, with the view of obtaining greater accuracy in the work and more particularly a certain interchangeability of the several parts of the breech mechanism of guns of the same caliber. Especial attention has been given to the very accurate threading of breechblocks, breech bushings and their recesses, and to the preparation of a complete and accurate set of templets and gauges for this work. Pending the preparation of these templets and gauges the work on the breechblocks, breech bushings, etc., has been suspended. This suspension has caused a temporary falling off in the number of completed guns during the year, but the improvements that have been made in the machinery and in the methods of manufacture will permit of making good, at an early date, the scheduled output, and even of exceeding it, if the funds for manufacture are available. A summary of the work completed and that in progress at the beginning and the end of the year is given in the following table:

Kind and caliber of cannon.	Under construction June 30, 1893.	Completed June 30, 1894.	Under construction June 30, 1894.
8-inch B. L. rifle, service	12	11	6
10-inch B. L. rifle, service	11	11	11
10-inch B. L. rifle, Crozier wire-wound, experimental	1	1	.....
12-inch B. L. rifle, service	6	6	7
12-inch B. L. mortar, steel service	2	1	6

All the cannon noted as in progress of construction are well advanced towards completion, the remaining work on many of them being only the threading, which has been delayed. It is expected that nearly all will be completed by the end of the present calendar year, so that the output at that time will conform very closely to the schedule of required output. There will then have been completed at the gun factory since the beginning of operations thirty 8-inch B. L. rifles, thirty-five 10-inch B. L. rifles, fifteen 12-inch B. L. rifles, eight 12-inch B. L. mortars, steel, exclusive of work on several wire guns of 10-inch caliber and a large number of field and siege guns, howitzers, and mortars.

The contract with the West Point Foundry Company for finishing and assembling eleven 8-inch guns from forgings supplied by the Department was completed in December, 1893. Under the one-hundred-gun contract with the Bethlehem Iron Company for supplying the Department with twenty-five 8-inch, fifty 10-inch, and twenty-five 12-inch guns, work is progressing satisfactorily. Ten 8-inch guns are under manufacture and a number of them are well along toward completion. A number of tubes and jackets and hoops for 10-inch guns have also been made. The company expects to make earlier deliveries than required by the terms of its contract.

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The sum of $250,000 is appropriated by the fortifications act of August 1, 1894, for the further purchase of gun forgings, and bids have accordingly been invited for five sets of 8-inch, five sets of 10-inch, and two sets of 12-inch gun forgings.

EXPERIMENTAL GUNS.

The Brown 5-inch segmental wire gun.—The test of this gun was completed during the past year, the total number of rounds fired being 192. After the one hundred and ninety-second round, which was with a charge of 36 pounds of brown prismatic powder giving recorded pressures of 50,956 and 48,450 pounds per square inch respectively in the two gauges used, two large cracks were discovered in the lining tube. The upper crack was about one-fourth of an inch wide at its widest part and the lower one slightly narrower. A considerable quantity of gas escaped from the outside under the front edge of the trunnion tube which had presumably passed through the staves and wire wrapping of the gun. The joints between the staves in the whole unlined (forward) portion of the gun were distinctly marked. The gun being thus rendered unserviceable, the test was suspended and permission given the company to remove it for dismantling. It was found upon removing the jacket that one of the segments had parted at about 34½ inches from the breech. The escaping gas had cut the wires at this point, leaving an opening about one-eighth of an inch wide—the full width of a segment—from lining tube to the space between wires and jacket. The escape of gas was thus accounted for.

The bore was considerably eroded and scored, but the segments, with the one exception, were intact. From the appearance of the broken segment it seems probable that rupture had taken place sometime before the discovery of the escape of gas, but how long before there were no means of determining.

The records of firing show that the gun was subjected to the following average pressures, viz:

45 rounds with pressures between 30,000 and 40,000 pounds per square inch.
51 rounds with pressures between 40,000 and 50,000 pounds per square inch.
43 rounds with pressures between 50,000 and 60,000 pounds per square inch.
2 rounds with pressures between 60,000 and 65,000 pounds per square inch.
1 round with a pressure of 65,900 pounds per square inch.
1 round with a pressure of 65,410 pounds per square inch.
1 round with a pressure of 76,500 pounds per square inch.
1 round with a pressure of 82,850 pounds per square inch.

Some of the higher pressures may undoubtedly be referred to wave action and to recognized defects of the measuring apparatus to meet as high pressures. Similar high pressures have been registered in our hooped steel guns of 8, 10, and 12 inch calibers, and which they have endured without apparent injury. During the progress of the trials 48 rounds were fired with Leonard smokeless powder and some excellent ballistic results obtained, although the pressures were intentionally

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high. The report on the trial of this gun forms an appendix to this report.

The Woodbridge 10-inch wire-wound gun.—This gun may be regarded, perhaps, as the prototype of the Brown segmental gun, to which it has many points of resemblance. The lining tube, however, extends throughout the entire bore, and the tensions of the wire wrapping, determined by Dr. Woodbridge himself, were in accord with that inventor's views as to this type of gun construction. The gun was completed in 1893 and was subjected to test at the proving ground during the past year. It was rendered completely unserviceable at the twenty-third round by rupture (splitting) of the inner tube in five places. The average pressures to which this gun was subjected in firing were as follows:

2 rounds, with pressures below 30,000 pounds per square inch.
13 rounds, with pressures between 30,000 and 40,000 pounds per square inch.
6 rounds, with pressures between 35,000 and 45,000 pounds per square inch.
1 round, with a pressure of 41,167 pounds per square inch.
1 round, with a pressure of 47,930 pounds per square inch.

In addition to this Woodbridge 10-inch wire-wound gun, the Department, upon the recommendation of the Getty board, tested a Woodbridge 10-inch wire-wound brazed gun in 1881, which was fractured and parted longitudinally at the ninety-third round; and in 1891–'92 a Woodbridge 10-inch cast-iron wire gun. This last gun was fired 161 rounds, using medium charges of brown prismatic powder, at the conclusion of which the board for testing rifled cannon, etc., appointed by act of Congress July 5, 1894, reported that in view of the inferior power of the gun and the considerable scoring and guttering developed during the limited test to which it had been subjected, it was not deemed a suitable gun to be put in service.

The Crozier 10-inch wire-wound gun.—The Department has now under test a third wire gun, manufactured under its auspices at the Watervliet Arsenal, known as the Crozier 10-inch wire-wound rifle. In essential features it consists of a rather heavy central tube of forged steel overlaid with a practically continuous layer of wire from breech to muzzle; a steel jacket carrying the breechblock and the trunnion hoop is placed over the wire covering with very slight shrinkage, and connected at its forward end with the tube; rings or hoops, principally for protection against missiles, are shrunk upon the chase.

The construction may be said to be conservative, the principal peculiarities being the arrangement of the tensions and shrinkages so as to relieve the jacket of a large portion of the strain without diminishing at all the strength of the gun, thus permitting the use of cheaper material for the jacket, and the method of coupling together the tube and jacket so as to prevent relative motion in a longitudinal direction, without interrupting the continuity of the winding.

This gun has now been fired 68 rounds, most of them with full pressures, the highest pressure experienced being 46,000 pounds per square

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inch. No sign of weakness has appeared, and the trial of the gun is still in progress. The knowledge to be obtained by the complete test of this gun is important to the subject of wire-wound construction.

It is claimed for wire-wound construction that, despite some weaknesses due to welds or splices in the wire and to the fastenings at the ends, the wire envelope furnishes means of obtaining greater strength than can be obtained with steel hoops in the built-up gun. Both theory and experience have proved, however, that with the built-up steel hoop envelope we have greater strength than the steel tube can be designed and constructed to withstand, nor have we yet reached the limit of strength in this built-up steel envelope. Therefore the limit of strength would appear to be the ultimate strength of the tube common to both systems, provided the envelopes have the same modulus of elasticity, and the claims for superior strength of the wire-wound envelope should reduce to the claim that with this envelope we may possibly obtain a greater reserve of strength for unusual or unexpected strains, or may arrive at the *required* strength more easily.

Another claim for the wire-wound system is that it is more economical. This is important, but the truth of the claim has yet to be demonstrated. Also, moderate increase of strength, if not absolutely necessary, and some reduction of cost, even if established, must be offset by the superior stiffness, permanence, and some other important advantages of the built-up system.

The Ordnance Department has since 1876 made tests of four wire-wound guns, heretofore described in this report, and has on trial one more—the Crozier gun herein described. As stated, all of these guns were manufactured by the department, except the 5-inch Brown segmental gun. All of the guns except the one still under trial, as has been stated in this report, have failed, but the 5-inch Brown segmental gun showed great endurance.

With the knowledge gained in the construction and test of the above-mentioned guns and the completion of the test of the 10-inch wire-wound gun now in progress, it is believed that sufficient knowledge should be accumulated to enable the Department to determine conclusively the merits and advantages of wire-wound gun construction versus the built-up steel construction now in use.

MORTARS.

The type 12-inch B. L. mortar, steel, has been fired to date 174 rounds with varying charges. It is expected that the test of this piece will be completed during the coming year. As noted above, about seven more of these steel mortars will be completed at the Army Gun Factory at the end of the present calendar year.

Some comparative firings have been made during the year between a cast-iron hooped, and the all-steel 12-inch B. L. mortar, to determine which mortar has the greater accuracy of fire.

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In the cast-iron, hooped mortar the rifling has an initial pitch of one turn in 40 calibers and a final pitch of one turn in 25 calibers, whilst in the all-steel mortar it has an initial pitch of one turn in 40 calibers and a final pitch of one turn in 20 calibers. In the first series of firings made for this comparison the targets with the two mortars were made on different days and under different conditions as regards the atmosphere, wind, etc., and a fair comparison could not be drawn. Subsequently a second series of firings was made, and in order to insure the same atmospheric conditions in making the targets the mortars were fired alternately and as nearly simultaneously as possible. The interval between shots was about one minute for the short range and two minutes for the long range. The charges were proportioned so as to give the same velocity with the two mortars. This velocity was 554 feet per second for the short range and 1,020 feet per second for the long range.

The weight of the projectiles was made the same for each range respectively, this weight being the same as that used in the firings to determine the charge.

In these latter firings both mortars were mounted on the new spring-return mortar carriage. The mean range, probable rectangle, etc, in both the first and second series of firings, are tabulated below:

Firings with 12-inch B. L. mortar, cast-iron hooped (60° elevation).

FIRST SERIES.

Date.	Number of rounds.	Powder weight.	Shell weight.	Mean range.	50 per cent zones.		25 per cent probable rectangle.	Remarks.
					Lateral.	Longitudinal.		
1893-'94.		*Lbs. Oz.*		*Yards.*	*Yards.*	*Yards.*	*Sq. yards.*	
Dec. 1-7	5	27 9	1,002	2,353	5.9	16.2	95.6	Calm.
Dec. 7-8	5	77 4	811	7,646	9.7	37.2	360.8	Calm.
Dec. 12	5	31 0	1,005	2,432	14.2	31.1	441.6	Strong and gusty 70° R. and R.

SECOND SERIES.

Apr. 3-7	5	29 8	1,014	2,496	6.9	15.5	107.0	Weak and shifty across.
Apr. 7	5	76 8	811	7,434	19.2	41.9	804.5	Weak and steady, 17° L. and F.

Firings with 12-inch mortar, steel No. 1 (60° elevation).

Apr. 3	5	32 0	1,014	2,464	15.8	3.9	61.6	Weak and shifty across.
Apr. 7	5	82 12	811	7,346	28.1	79.1	2,222.7	Weak and steady, 9° L. and F.

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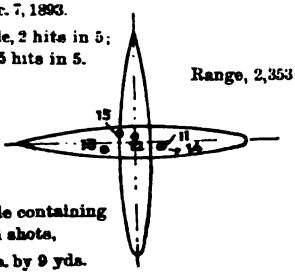
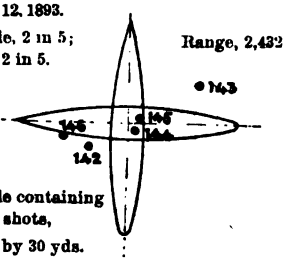
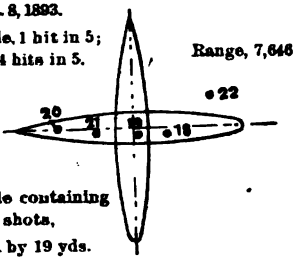
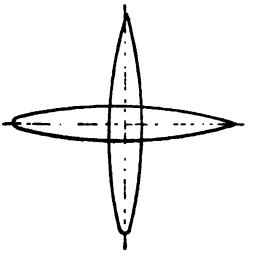
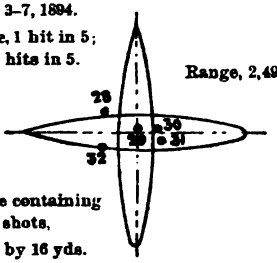
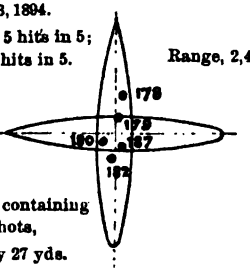
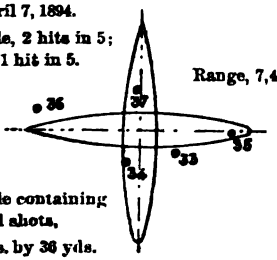
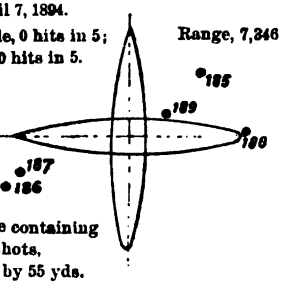
The accuracy of fire may be otherwise represented graphically as follows:

PLOTTING OF SHOTS TO SCALE WITH DECK OF U. S. S. PHILADELPHIA.

Direction of fire.

Cast Iron Mortar 51.	Steel Mortar.
Dec. 7, 1893. Broadside, 2 hits in 5; Bow on, 5 hits in 5. Range, 2,353 yds.  Rectangle containing all shots, 28 yds. by 9 yds.	Dec. 12, 1893. Broadside, 2 in 5; Bow on, 2 in 5. Range, 2,432 yds.  Rectangle containing all shots, 62 yds. by 30 yds.
Dec. 8, 1893. Broadside, 1 hit in 5; Bow on, 4 hits in 5. Range, 7,646 yds.  Rectangle containing all shots, 75 yds. by 19 yds.	
April 3–7, 1894. Broadside, 1 hit in 5; Bow on, 4 hits in 5. Range, 2,496 yds.  Rectangle containing all shots, 22 yds. by 16 yds.	April 3, 1894. Broadside, 5 hits in 5; Bow on, 3 hits in 5. Range, 2,464 yds.  Rectangle containing all shots, 8 yds. by 27 yds.
April 7, 1894. Broadside, 2 hits in 5; Bow on, 1 hit in 5. Range, 7,434 yds.  Rectangle containing all shots, 100 yds. by 36 yds.	April 7, 1894. Broadside, 0 hits in 5; Bow on, 0 hits in 5. Range, 7,346 yds.  Rectangle containing all shots, 119 yds. by 55 yds.

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The results obtained are slightly in favor of the cast-iron mortar for the length of projectile employed, but the results obtained with the steel mortar are so good that, taken in connection with the shorter pitch of its rifling, which will permit of using a longer high-explosive shell of greater capacity for an interior charge, it was decided to adopt the latter rifling for the new steel mortars.

GUN CARRIAGES.

Of the new model 8-inch barbette carriages, seven have been completed during the year at Watertown Arsenal; also three 12-inch barbette carriages. Two of the 8-inch carriages have been issued to the service, one each to West Point and Fort Monroe. There are still under manufacture at this post two 12-inch barbette carriages and four 12-inch gun-lift carriages.

The completion of these carriages has been delayed by the failure of the steel makers to produce sound castings, but as many of their parts are now far advanced, if the steel castings to be delivered prove satisfactory, the completion of the carriages is but a matter of several months work. There are also in course of construction five 10-inch barbette carriages. The contract for the steel parts of these carriages has been let, and the entire lot should be completed this fiscal year.

The designs of these various carriages had to be worked out in all details, patterns, etc., made, and improvements added as they were suggested during the progress of the work. The machine tools capable of doing the work required on them had to be purchased and set up. In view of these facts it is thought that commendable progress has been made.

ALTERATION OF CARRIAGES.

The improvements and changes in progress in the shops at Watertown Arsenal during the past year left over a great part of the work in that year in the alteration of 15-inch smooth bore and 8-inch converted rifle carriages. This work thus left over has since been completed, making a total of twenty-three 15-inch carriages and nine 8-inch carriages completed during the fiscal year.

EXPERIMENTAL CARRIAGES.

Gordon 10-inch disappearing gun carriage.—This carriage consists of a heavy bed plate supporting two side frames which carry the movable parts on journals, and a pivot plate firmly fastened to the under surface of the bed plate, the whole resting on a heavy cast-iron platform or traverse circle.

The gun is mounted on a top carriage, which is connected with the inner arms of four double cranks journaled into the side frames, two on each side. The counterpoise frame is mounted on the outer ends of the crank arms. During recoil the gun, top carriage, and counter-

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weight rotate about their journals, the gun and top carriage describing an arc of about 180° to reach the loading position, while the counterweight describes an equal opposite arc rising while the gun falls. The gun, top carriage, and counterweight remain parallel to their original position throughout the motion. Between the side frames and secured to the bedplate are two hydraulic cylinders, 12 inches in diameter, which are connected by means of check valves with the air chamber placed above and across their front ends. The piston rods are connected by means of intermediate rods with the top carriage, so that during recoil the piston rods are pushed to the front, thus forcing the liquid from the cylinders through the check valves to the air chamber. Sufficient energy is thus stored in the air chamber to elevate the gun into the loading position. The by-pass valves are opened for this purpose.

A small air pump is used to give the required initial pressure in the air chamber. For the purpose of maneuvering the carriage by hand a system of gearing is attached to each side of the counterweight frame. The carriage is lifted on an oil pivot for traversing and a small hydraulic pump is provided for this purpose. Except when raised for traversing the carriage is in complete contact with the platform. The construction is very massive, the top carriage alone weighing upwards of 70 tons and the total weight amounting to over 200 tons. The main parts are of cast iron, the cheeks of the top carriage and the cranks and journals being of steel.

Preliminary to the official test, some fifteen rounds were fired for the purpose of developing the working of the carriage and making adjustments and minor alterations. The carriage was then subjected to test in accordance with a carefully prepared programme. During these firings some minor changes were found necessary for the convenient working of the carriage. The following are some of the results obtained:

Time required to raise the carriage from the firing to the traversing position, 30 seconds, eight men working at the pumps.

The facility with which the carriage might be traversed could not be ascertained, owing to the fact that the platform on which it was mounted had, during the preliminary firing, settled on one side so that its upper surface was not horizontal. This caused the pintle to bind in its seat and prevented the carriage from turning, except through a small arc.

It was the opinion of the Ordnance Board, which conducted the test, that the traversing could be done with ease by four men, two at each end of the counterweight.

The time required for passing from an elevation of $-5°$ to $+20°$ was 15 seconds, four men being required.

The time required to properly charge the air chamber for half a charge (125 pounds) of powder was found to be 9 minutes, and for a full charge (250 pounds) of powder, 41 minutes 18 seconds, ten men working at the pump.

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The time required to raise the gun from loading position was 2 minutes 7 seconds.

In the firings for rapidity ten rounds were fired to sea, six being continuous, without delay on account of ships or other obstructions; from these firings the board determined that the actual time required for ten rounds was fifty-eight minutes twenty-eight seconds.

Thirty-three rounds were fired in all in making these official tests. A number of defects or disadvantages in the system were developed during the test, some of which were inherent and beyond remedy, while others were such as could be overcome in future construction. Considering the results as a whole, the board was of opinion that the carriage mounted on a properly constructed platform possessed many advantages and desirable features, and it was thought that with the modifications requisite to overcome the defects noted during the trial it would prove a suitable carriage for issue to the service.

The Report of the Ordnance Board on the test of this carriage was communicated to the Board of Ordnance and Fortification, and that board decided, in view of the results obtained and in consideration of statements submitted by Capt. W. B. Gordon, to purchase a modified 10-inch carriage of the Gordon design. This board informed the Department that, in its opinion, the existing carriage did not present the best development of the Gordon system, and the carriage, to be compared with the Crozier and pneumatic systems, should be the modified Gordon carriage. The board further stated that such satisfactory results had been obtained from the original carriage as to indicate that one maneuvered entirely by hand, without the necessity for using a steam engine, could be produced, and such being the case, it would be premature to continue experiments with carriages which, like the pneumatic, can only be maneuvered with power.

The report of the Ordnance Board on the test of this carriage forms an appendix to this report.

Pneumatic 10-inch disappearing carriage.—As stated in my last annual report, this carriage was turned over to the Department by the Board of Ordnance and Fortification for such additional tests as might be deemed desirable to determine the fitness of the carriage for the service.

Subsequently, under date of October 5, 1893, the Board of Ordnance and Fortification reconsidered its previous action, proposing further test of the pneumatic carriage, and modified their recommendations so far as to postpone such firings at least until after the modified Gordon and the 10-inch Buffington-Crozier carriages, both of which are designed for hand power, have been tested; it having been made apparent to the board by the test of the original Gordon carriage that a hand-power carriage is practicable, and the further test of types necessitating the use of steam power was therefore deemed an unwise and unnecessary expenditure of money.

By the fortifications act of August 1, 1894, Congress appropriated

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$50,000 to procure and test an improved 10-inch pneumatic disappearing carriage, to be made upon plans prepared by the Pneumatic Gun Carriage and Power Company, of Washington, D. C.

Buffington-Crozier 8 and 10 inch disappearing carriages.—In this type of carriage the gun rests by its trunnions on the upper ends of two cast steel rotating arms, in bearings bushed with bronze. The arms are pivoted near their middle points upon an axle of forged steel, and are connected beneath the gun by a plate transom. The axle rests in bearings in the top carriage, which is formed with the two hydraulic cylinders in two pieces of cast steel bolted together. In each cylinder are two throttling bars of steel, which pass through notches in the piston and serve to regulate the size of the orifice for the flow of the liquid past the pistons by a variable cross section.

The hydraulic cylinders are connected by a pipe at their forward ends to equalize the pressure in them during recoil. The pistons are fastened by means of nuts to projections on the chassis.

The top carriage runs upon rollers of forged steel, which are placed in recesses of the cheek plates of the chassis. The cheek plates are of cast steel and are connected by transoms. They are bolted at the forward ends to the upper front roller path, which rests upon a live roller ring. The rear of the chassis rests upon the rear traverse wheels This arrangement provides for traversing the carriage, and it is effected by means of gearing worked by hand power. The counterweight is suspended from a shaft joining the lower ends of the rotating arms This shaft of forged steel passes through the lower ends of the arms into the two sliding pieces, forming a crosshead.

Crosshead keys are formed on one side of the chassis.

A vertical ratchet is formed on the inner face of each crosshead piece, to be caught by a pawl on the cheek plate to hold up the counterweight. This pawl is mounted upon a short crank actuated by a long lever at the side of the carriage, which arrangement is used for lowering the piece should the recoil be not quite sufficient. The well for the reception of the counterweight is at the front of the carriage and inclosed by the front roller path.

The 8 and 10 inch carriages are similar in all essential features, the parts of the 10-inch being made stronger and heavier in proportion to the increased caliber of the gun for which it is intended, and for the better control of the movements of the gun, especially into battery, the chassis rollers are inclined 3° instead of being horizontal, as in the 8-inch gun. A special arrangement is also made in the 10-inch carriage for moving the gun from the firing to the loading position by hand.

The action of the carriage is as follows:

Upon firing the piece, the central pivot of the rotating beam moves horizontally to the rear, carrying the top carriage with it; the lower end moves vertically upward being constrained by the crosshead guides; the gun moves downward and to the rear in the arc of an

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ellipse. The energy of recoil is absorbed partly by raising the counterweight and partly by the resistance of the hydraulic cylinders. After loading the pawls are tripped and the greater moment of the counterweight raises the piece into battery. The piece is hauled down into loading position by hand, for loading and cleaning, by blocks and falls attached to the upper ends of the rotating arms and to lugs on the cheek plates.

The firings with the 8-inch carriage were begun November 14, 1893. Preliminary to the official test twenty-eight rounds were fired with varying charges in developing the working of the carriage and making the necessary adjustments in the obturating bars and the counterweight.

The following are some of the results obtained in the official test:

Time of traversing through an angle of 54°, with the gun in the firing position and 2 men at the cranks—1 minute 13½ seconds.

Time for passing from elevation —5° to +14°, with the gun in the firing position and 2 men at the elevating wheels, 13¾ seconds.

Time for passing from an elevation of +14° to —5° with four men at the elevating wheels, 20 seconds.

Time for traversing through an angle of 54° with the gun in the loading position and four men at the cranks, 1 minute 14½ seconds.

Time for passing from elevation of —5° to +14° with the gun in the loading position and two men at the wheels, 8¾ seconds.

Time for passing from elevation of +14° to —5° with the gun in the loading position and four men at the wheels, 18 seconds.

Time for raising from the loading to the firing position, with two men to trip the pawls, 4 seconds.

In the test for rapidity ten rounds were fired without mishap of any kind in 12 minutes 21 seconds, the pawls catching each time and the piece, upon tripping them, returning entirely to the firing position.

The gun detachment consisted of 1 noncommissioned officer and 9 men. The time might have been somewhat reduced if the detachment had not taken cover at each firing.

In all, forty-seven rounds were fired with the carriage. No breakage or any other accident of any description occurred in all the trials of this carriage. In addition to the modifications affecting the throttling orifices, some slight changes were made for the purpose of increasing the facility of maneuvering.

The Ordnance Board, which conducted the tests, reported as follows:

The test of this carriage has demonstrated that it possesses in a marked degree the properties which should pertain to a disappearing carriage for high-power guns.

It is simple in construction, so that its parts and their purposes are easily understood.

Loading and maneuvering are effected by operations which are accomplished by hand with ease, certainty, and great rapidity, *and these operations simulate very closely those required with the barbette carriages already adopted by the Department.*

* * * * * * *

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While the carriage as it stands is considered by the board in all respects fit for use in the service, it might be modified to advantage by adding a more efficient counter recoil buffer, and by increasing the facilities for hauling down by hand, and the depth of the well for counterweight might be diminished by using lead instead of iron for the counterweight.

The design of this carriage has since been modified, considerably reducing its size and weight and cost of production and increasing its efficiency.

The report of the Ordnance Board on the test of this carriage forms an appendix to this report.

The test of the 10-inch Buffington-Crozier carriage was commenced on July 6, 1894, the 10-inch Crozier wire gun being mounted on the carriage. The first thirty rounds were fired with varying charges, for the purpose of making adjustments and for testing certain samples of powder in order to obtain data for working up a suitable powder for the experimental wire gun used in the test.

The following are some of the results obtained:

Time for traversing with gun up, through 48° 56′, two men at each handle, four men in all, 1 minute 59½ seconds.

Time for passing from elevation of −4° 20′ to +16°, gun up, two men at each wheel, four men in all, 31 seconds.

Time for passing from elevation of +15° to −4° 20′, 34¾ seconds.

Time for bringing gun from firing to loading position, by hand, four men at each handle of the windlass and one at each fall, ten men in all, 11 minutes 33¼ seconds.

Time for traversing, with gun down, through 48° 56′, two men at each handle, 2 minutes 5¾ seconds.

Time for passing from elevation of −4° 20′ to +16°, gun down, two men, one at each wheel, 30 seconds.

Time for passing from elevation of −4° 20′ to +16°, gun down, four men, two at each wheel, 20 seconds.

Time for passing from elevation of +16° to −4° 20′, two men, one at each wheel, 54 seconds.

Time for passing from elevation of +16° to −4° 20′, four men, two at each wheel, 29 seconds.

Time for raising the gun from loading to firing position, two men, one at each pawl, 11½ seconds.

In the rapidity test the total time required for firing the ten rounds was 22 minutes 19$\frac{8}{10}$ seconds, from which must be deducted 7 minutes 38 seconds, due to imperfect working of the breechblock as noted in the record, leaving the time actually required for ten rounds 14 minutes 41$\frac{8}{10}$ seconds. The record made with this gun increases the standard for rapidity for guns of this caliber mounted on disappearing carriages to ten rounds in 15 minutes, or to the rate of forty rounds per hour.

The Ordnance Board, in its report on the test of this carriage, states that "the advantages of this system of disappearing carriage, as setforth

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in the report of the board on the 8-inch carriage, are confirmed and emphasized by the trial of a carriage adapted for a gun of much greater caliber and power, and it is the opinion of the board that the exhaustive test to which this system has now been subjected demonstrates that on account of the simplicity of its construction, involving no valves, pumps or other complicated appliances, and the fact that by methods easily understood by the average artillery soldier the operations of loading and maneuvering are effected with remarkable ease, certainty, and rapidity, it is worthy of adoption for use in the service on all sites except those where an all-around traverse is absolutely necessary."

The board suggested some slight modifications that might with advantage be made in the carriage and which can be readily embodied in future constructions.

Sixty-eight rounds in all have been fired from this carriage. The report of the Ordnance Board on the test of this carriage forms an appendix to this report.

Gruson 12-inch minimum-port carriage.—This carriage, purchased from the Grusonwerk, Magdeburg-Buckau, Prussia, was received during the past year and set up on suitable foundations at the proving ground. The test of this carriage, under the supervision of the Ordnance Board, was commenced several months ago, but owing to the breakage of one of the cast-iron parts the trials were discontinued until the broken part could be replaced by a steel casting. The carriage will soon be in condition for continuing the test. The Department has purchased the right to manufacture carriages of this type, for guns of different caliber, from the Grusonwerk.

MORTAR CARRIAGES.

Contracts for 64 spring-return 12-inch mortar carriages have been completed during the year, and a number of these carriages, with their mortars, have been issued to the service and set up in the new batteries prepared for them by the Engineer Department.

The contract with the West Point Foundry Company for 7 spring-return carriages for mounting the 12-inch steel mortars will be completed during the present month. The Department will then have completed in all 80 of these carriages.

The West Point Foundry Company has also manufactured for the Department an experimental 12-inch spring-return mortar carriage on a plan designed by Capt. William Gordon, of the Ordnance Department. This carriage is now at the Sandy Hook Proving Ground awaiting test. It is simple in construction, and if it passes its test satisfactorily it may prove to be more economical in manufacture than the present type of carriage.

During the past year a mortar carriage with its platform for the 7-inch B. L. siege mortar has been manufactured at the Watertown Arsenal. This carriage is now at the proving ground at Sandy Hook, and, with its mortar, will soon be subjected to test.

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As indicated in my last annual report, spiral springs have been adopted in place of Belleville springs for these spring-return mortar carriages. Appended to this report is a report by the Ordnance Board on the test made of these spiral springs, and the conclusions of the board thereon show their entire suitableness for this purpose. The cost of the springs is about one-third the cost of the Belleville springs, and it is believed they will prove more durable and satisfactory in service.

The Pneumatic Gun Carriage and Power Company has constructed and submitted to the Department for trial a 12-inch mortar carriage on the pneumatic system. Preparations are now in progress at the proving ground for mounting this carriage for test.

PROJECTILES.

Armor-piercing shot.—During the year the Midvale Steel Company has completed its contracts for supplying the Department with armor-piercing shot, made by the Holtzer process, combined with certain improvements introduced by the Midvale Steel Company. The number of shot furnished under these contracts are as follows:

8-inch armor-piercing shot	318
10-inch armor-piercing shot	430
12-inch armor-piercing shot	159

The Department has also a contract with the Carpenter Steel Company, of Reading, Pa., for 100 12-inch armor-piercing shot, which is not completed. Sufficient funds were appropriated by the fortifications act of August 1, 1894, to procure from 60 to 75 additional 12-inch armor-piercing shot, and bids therefor will soon be invited.

Efforts are being made here and abroad by the manufacturers of armor-piercing shot to produce projectiles that will penetrate, without breaking up, Harveyed or otherwise hardened plates. Some experiments have recently been made in this direction in Russia with Holtzer projectiles modified for the purpose, but with no marked success, and the Holtzer firm, it is understood, is also making investigations and experiments with projectiles of this description. It is quite probable, however, that the most satisfactory solution of this question will be to increase the caliber of the gun, and thus the mass of the projectile which is to be pitted against a given thickness of plate. This probability emphasizes the already admitted necessity for 16 inch guns in our seacoast defense.

Deck-piercing shell.—The contract with the Sterling Steel Company for deck-piercing shell has been completed by the delivery of the 235 shell required.

The contractors finally met the contract requirements in producing shell that would penetrate, without breaking up or material deformation, steel plates of 4.5-inch thickness set up at 60° to the horizon and solidly backed with oak. They have also furnished some experimental

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deck-piercing shell of 1,000 pounds weight, when charged, which have successfully withstood this ballistic test. With the funds available, the Department has invited bids for 275 additional projectiles of this class of 800 pounds weight.

PNEUMATIC DYNAMITE GUNS.

The trials by the Ordnance Board of the battery of pneumatic dynamite guns at Sandy Hook was concluded September 10, 1894. The board has reported that the requirements of the contract, specifications, and programme of tests have been complied with, except as follows: The flight of the 15-inch full caliber shells was not perfectly smooth; the accuracy of these shells, however, exceeds the requirements. The delay-action fuse when set for two seconds worked satisfactorily, but not when set for less time. It is believed this defect in the fuse can be remedied in future constructions. In traversing the 15-inch gun by hand, the time occupied in passing over 360° was more than eight minutes with six men at the handles and four for relays. The Department has approved the opinion of the board that these slight defects should not prevent the acceptance of the battery; and the guns—one 8-inch and two 15-inch—with their carriages, power plant, and all accessories, complete and mounted in place ready for military use, besides a limited supply of projectiles ready for use, except the explosive charge, have been accepted.

These deliveries have been made by the Pneumatic Torpedo and Construction Company, under contract of January 27, 1893. The provision for their purchase is contained in the Army act for the fiscal year ending June 30, 1889, approved September 22, 1888.

The same contract includes the installation of a battery of three 15-inch guns on the Pacific coast, for which provision was made in the Army act of the next succeeding year, approved March 2, 1889. Two of these guns and accessories are nearly ready to ship to their destination, and the manufacture of the third is in progress. The company has been granted an extension of time until April 27, 1895, in which to complete the work.

The present contract with the Pneumatic Torpedo and Construction Company was made by the Department in consequence of the failure of the original contractors, the Pneumatic Dynamite Gun Company, to complete the work as agreed upon. The last-named company was operating under two contracts with the Department, one dated March 6, 1889, for guns on the Atlantic coast, and one dated June 10, 1889, for guns on the Pacific coast, which are more specifically referred to on page 27 of the annual report of the Chief of Ordnance, U. S. Army, for 1889. In making the new contract these two were consolidated, and at the same time the number of guns to be mounted on the Atlantic coast was reduced from seven to three. This reduction comprised four 15-inch guns, which were to have been mounted in batteries of two guns each, at Fort Schuyler, N. Y., and Boston, Mass.

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RAPID-FIRE GUNS.

Six-pounder rapid-fire guns.—The tests of a number of 6-pounder rapid-fire guns, caliber 2.24-inch (57 mm.), of various designs, have been undertaken and completed during the past year. These guns comprise the following, viz: Driggs-Schroeder, Hotchkiss, Sponsel, Seabury, and Maxim-Nordenfeldt. Most of these guns were submitted by the manufacturers or inventors free of cost, and the Department furnished the ammunition, etc., for the test.

The guns were all subjected to the same test in accordance with a comprehensive program carefully prepared by the Ordnance Board. At the time of this writing, the report of the board has not been received, but it will be added later as an appendix to this report.

No marked differences in merit were developed in the tests, and each type had its special excellencies for particular purposes.

In connection with the tests of the 6-pounder guns a 1.85-inch(47 mm.) rapid-fire gun, submitted by the Skoda Steel Works, of Pilsen, Austria, was subjected to the same programme of tests as the other guns, though not considered to be in competition with them. The Skoda Steel Works furnished both the gun and the ammunition for test without charge to the United States.

12-CM. rapid-fire guns.—Guns of this caliber, and of different type, have been ordered or purchased by the Department for test as follows: Hotchkiss, Armstrong, Creusot, and Canét. The first three guns were received some time ago, but great and perhaps unavoidable delays have prevented the delivery of the Canét gun up to the date of this writing, and the comparative tests have been postponed on that account.

The Canét gun is expected to arrive shortly, and as soon as received the tests will be taken in hand. This caliber of rapid-fire guns was proposed by the Engineer Department for the defense of submarine mine fields. The smaller calibers, as the 6-pounder, are for general purposes of coast defense.

SIEGE MATERIAL.

The ten 5-inch B. L. rifles noted in my last annual report as under manufacture at the gun factory are nearly completed. The ten 7-inch B. L. howitzers are entirely completed.

The plant for the manufacture of the carriages for these guns is now fully established at the Rock Island Arsenal and the carriages are in process of manufacture. Considerable trouble and delay has been experienced in obtaining sound and suitable steel castings for their manufacture.

The experimental 7-inch B. L. mortar, contrary to anticipation, is not completed, owing to the delays that have occurred at the gun factory in connection with the threading of breech-blocks, etc., as explained in

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the paragraph on seacoast guns. This piece will, however, be completed before January 1, 1895.

As already noted, the carriage and platform for mounting it are now at the proving ground.

FIELD MATERIAL.

During the past year some twenty-three 3.2-inch and twenty-two 3.6-inch field guns have been completed at the gun factory. There are still under manufacture twenty-five 3.2-inch field guns.

The Department has funds available for the manufacture of about forty more 3.2-inch guns, but before proceeding with their manufacture it is desired to determine by experiments the dimensions of chamber best suited to the use of smokeless powder and a system of breech mechanism adapted to the use of metallic ammunition and to service requirements. Two 3.2-inch guns have each been fitted with a breech mechanism provided with a cartridge-case extractor and firing device suitable for use with metallic ammunition. One is the Driggs system and the other the Gerdom. The tests of these guns are still in progress, and no definite conclusions have been reached with respect to their merits, though it seems quite probable that one or the other will prove a satisfactory type for service.

The proposed metallic ammunition for 3.2-inch field guns comprises a projectile weighing 16½ pounds, with a suitable charge of smokeless powder to give an initial velocity of 1,450 feet per second, with a pressure not exceeding 30,000 pounds. The progress of experiments now being made at the proving ground with samples of smokeless powder of domestic manufacture, ordered especially for this purpose, as well as of some foreign samples on hand, indicates that the length of powder space in the gun can be considerably reduced with smokeless powder and that a fixed cartridge of convenient length will be obtained. In the meantime investigations are in progress to find a suitable grade of aluminum alloy of which to make the cartridge case and so reduce the total weight of the metallic ammunition to the least practicable limit.

The report of firings made at the Sandy Hook Proving Ground to determine range tables for the 3.2-inch field gun with shell and shrapnel of 13½ pounds weight, is appended.

CHANGES IN MATERIAL.

New belts for .30-caliber ammunition, with loops arranged in two tiers to carry 100 rounds, have been issued with the ammunition, and their color, which is a dark blue, is believed to make them more sightly and durable than the gray belts heretofore in use.

In issuing the magazine rifle one arm chest to each company is fitted with hinges, hasps, staples, and padlocks, to be used for the storage of surplus arms, and it has been found necessary to issue new portable arm racks, which, for the infantry, are designed also to contain three revolvers, caliber .38.

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The practical difficulties in the way of reloading the service ammunition with smokeless powder render it unnecessary, even if it were desirable, to issue reloading tools for this purpose, and it will be necessary for officers to return their empty shell to Frankford Arsenal, for which they will be given credit in computing their money allowance for target practice. Tools, however, are issued for decapping and cleaning fired shell.

For gallery practice special shell have been ordered issued which can be reloaded with black powder.

The cavalry were equipped with the Colt double-action revolver, caliber .38, at the time predicted in my report of last year, and a woven attachment, to be added to the new belt, has been prepared for carrying its ammunition. Defects have been discovered in the revolver due to very rough, if justifiable, treatment, but it is thought they have been overcome.

Upon the recommendation of the Major-General Commanding the Army it has been decided to retain, for the present, the Colt revolver, caliber .45, for the light batteries, and experiments are now being made at the Springfield Armory to ascertain if a shorter barrel could not be advantageously used for this arm.

Two additional sizes of surcingles have been added to the supply table:

No. 1 (G. O. 73, A. G. O., 1885) having a total length, with billet, of 76½ inches;

Nos. 2 and 3 having a total length of 84 and 96 inches respectively.

The rear standard for carriage for mountain gun pack has been altered so as to raise the carriage seats 2 inches in order to relieve the backs of the pack animals, and blinders have been added as a part of the harness of the pack outfit.

The steel horse collars heretofore in experimental use have been slightly modified in shape. They have given great satisfaction, and the light batteries are now being fully equipped with them.

The rear sights for 8-inch converted M. L. rifles made since 1891 have a diagonal scale and vernier slide, moved by a translating screw on the vertical limb, which may be read to 1 minute of arc in elevation; they also have a graduation on the horizontal limb, of which each division is one one-thousandth of the distance between the front and rear sights and gives, therefore, a proportionate deflection scale for range. The pattern of these sights made prior to 1891, which is described and illustrated in Ordnance Memoranda No. 24 (1884), has now been altered to conform as nearly as practicable to the later model. On being turned into the Frankford Arsenal, accompanied by the sight bracket, these sights, of which there are a number in use, are altered as follows:

The graduation on the vertical limb is made to give direct reading to five minutes of arc in place of fifteen as heretofore, and the graduation of the horizontal limb is changed to give a deflection scale in one-thou-

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sandths of the range. The difference in size of shank between the old and new patterns is also corrected and interchangeability of both patterns in their sight sockets secured by enlarging the shank of the old sight and also enlarging its sight socket to be identical with that of the later model. Descriptive drawings of the model 1891 sight and of the modified prior sight are appended.

INSPECTING INSTRUMENTS.

On account of the conical shape of the cavity in armor-piercing projectiles, ordinary appliances or calipers can not be used to measure, with accuracy, the eccentricity of the shot in their inspection.

There is appended to this report a description of a valuable instrument—an eccentric caliper—for making such measurments, which has been devised and constructed by the department during the year.

EXPERIMENTAL MATERIAL.

Range finders for artillery and infantry.—A number of range finders procured by the Department within the past few years have now, with the approval of the Major-General Commanding the Army, been issued for trial and report, as follows:

To the School of Application at Fort Riley, Kans., one sample each of the Erle, Weldon, Aide-Tireur, and Nolan range finders, and Unge telemeters; and

To the Infantry and Cavalry School, at Fort Leavenworth, Kans., one each of the Watkins and Broad-arrow range finders, one set of mekometers, and one Labbez telemeter.

Friction primers for field guns with axial vent.—The use of an axial vent through the breech-block spindle, in the field guns of present manufacture (model 1890), has necessitated an attachment to the friction primers by which it will be retained on the lanyard hook when fired and prevented from being projected to the rear to the injury of persons standing behind the gun. The form of this attachment, now under trial, consists of a thin brass wire about 18 inches in length, looped or coiled for convenience, and having one end fastened in the loop of the friction wire and the other around the head of the body of the friction primer.

Aluminum equipments.—Experiments with articles of equipments made of aluminum and its alloys have been continued during the year at various posts and at the Rock Island Arsenal, and very intelligent assistance has been given to the department by manufacturers. Successful results have been obtained in the production of spurs, waist-belt plates, and several minor articles; but in those cases in which, from their importance as articles of considerable weight, success was hoped for most—such as bits, cups, meat cans, picket pins, and horse-shoes—the desired quality of metal has not yet been obtained. A very promising canteen has been designed, but not yet tested by the

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department, and experiments will be continued as rapidly as possible.

Intrenching tools.—Modifications having been made in the Babcock spade-hatchet and the Patterson and the Kahan intrenching tools they will be submitted, together with the Luther intrenching tool, the knife bayonet for the magazine rifle, and designs presented by Col. Bell and Capt. Zalinski, to a board for trial and report.

Designs are now under consideration with a view to selecting a knife to constitute the side arm for the cannoneers of the light batteries, and experiments are being continued with various articles of accouterments and equipment.

An attachment for the Springfield rifle, for use in gallery practice with field guns, was made at Springfield Armory, and is now at the Light Artillery School undergoing test.

Several designs for moving targets have been submitted, which are ingenious and highly recommended, but their cost is so great that in view of the extent of the appropriations it has not been feasible to manufacture them.

I have the honor to submit herewith the following papers as appendices to this report:

Appendix 1.—Report of action taken during the year ended June 30, 1894, under the provisions of the act approved March 3, 1881.

REPORTS FROM SPRINGFIELD ARMORY.

Appendix 2.—Report of principal operations.

REPORTS FROM FRANKFORD ARSENAL.

Appendix 3.—Progress report on manufacture of .30-caliber ammunition—1 plate.

Appendix 4.—Reports upon test of .30-caliber lubricated and non-lubricated bullets, and materials for bullet jackets.

Appendix 5.—Reports upon test of cupro-nickel steel as material for .30-caliber bullet jackets.

Appendix 6.—Report of experiments with .30-caliber service and tubular bullets (5 plates).

Appendix 7.—Trajectories of .30-caliber service and the Hebler tubular bullets (1 plate).

Appendix 8.—Specifications for smokeless powders for .30-caliber small arms.

Appendix 9.—Report of test of smokeless powders for small arms.

Appendix 10.—Investigations and tests of smokeless powder in chemical laboratory.

Appendix 11.—Description of eccentric calipers for armor-piercing projectiles (1 plate).

Appendix 12.—Manufacture of crusher gauges for cannon (5 plates).

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REPORTS FROM BENICIA ARSENAL.

Appendix 13.—Tests of powders and small-arm bullets.

REPORTS FROM WATERVLIET ARSENAL AND ARMY GUN FACTORY.

Appendix 14.—Report of principal operations (6 plates).

REPORTS FROM WATERTOWN ARSENAL.

Appendix 15.—Report of principal operations (1 plate showing modified Piper gin).

Appendix 16.—Description of barbette carriage for 12-inch B. L. rifle (16 plates).

Appendix 17.—Description of double horizontal boring machine, built at Watertown Arsenal (7 plates).

REPORTS FROM ORDNANCE PROVING GROUND.

Appendix 18.—Report of principal operations (2 plates).

Appendix 19.—Summary of tests of smokeless powders.

Appendix 20.—Report of firings made with Woodbridge 10-inch B. L. rifle, wire wound.

Appendix 21.—Report of firings made with 12-inch B. L. mortars to determine pitch of rifling (6 plates).

Appendix 22.—Range table for 3.2-inch B. L. field gun, steel (3 plates).

Appendix 22a.—Accuracy trials of a worn 8-inch rifle with enlarged rotating band (2 plates).

MANUFACTURE OF POWDERS.

Appendix 23.—Report of the inspector of powder.

CONSTRUCTION OF ORDNANCE.

Appendix 24.—Progress report on the manufacture of steel forgings, castings, etc., at the Midvale Steel Works, Philadelphia, Pa.

Appendix 25.—Progress report on manufacture of steel forgings, etc., at the Bethlehem Iron Works, South Bethlehem, Pa.

Appendix 26.—Progress report on the manufacture of ordnance at the West Point Foundry, Cold Spring, N. Y.

REPORTS FROM ORDNANCE BOARD.

Appendix 27.—Test of Gordon disappearing carriage for 10-inch B. L. rifle.

Appendix 28.—Test of Buffington-Crozier disappearing carriage for 8-inch B. L. rifle.

Appendix 29.—Test of Buffington-Crozier disappearing carriage for 10-inch B. L. rifle.

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Appendix 31.—Report upon the dismantling of the Brown 5-inch segmental wire-wound gun (2 plates).

Appendix 32.—Tests of a battery of pneumatic dynamite guns at Sandy Hook, N. J. (5 plates).

TEST OF 6-POUNDER RAPID-FIRE GUNS.

Appendix 33.—Test of Driggs-Schroeder gun (8 plates).

Appendix 33A.—Test of Sponsel gun (3 plates).

Appendix 33B.—Test of Hotchkiss gun (8 plates).

Appendix 33C.—Test of Maxim-Nordenfeldt gun (8 plates).

Appendix 33D.—Test of Seabury gun (8 plates).

Appendix 34.—Test of spiral springs for spring-return 12-inch mortar carriages (1 plate).

Appendix 35.—Report of experiments made to render more easily observable the smoke from bursting shrapnal or shell.

Appendix 36.—Progress report upon experiments made to determine dimensions of cartridge cases for 3.2-inch gun using smokeless powder.

MISCELLANEOUS.

Appendix 37.—Specifications for smokeless powders for field, siege, and seacoast guns.

Appendix 38.—Annual report of chief ordnance officer, Department of the Platte.

Appendix 39.—Report by O. W. Albee, M. E., assistant ordnance inspector at the Midvale Steel Works, on the manufacture of forgings and castings for St. Mary's Falls Canal lock gate, furnished by the Midvale Steel Company, for the Engineer Department, U. S. Army.

Appendix 40.—Sights for 8-inch M.L. rifle (3 plates).

I have the honor to be, very respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The SECRETARY OF WAR.

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APPENDIX 1.

Report of action taken under the act of March 3, 1881, during the fiscal year ended June 30, 1894.

March 10, 1894. Purchased from Bernard Peyton 10,000 pounds hexagonal powder, at 25 cents per pound..... $2,500

APPENDIX 2.

SPRINGFIELD ARMORY,
Springfield, Mass., September 28, 1894.

SIR: I have the honor to submit the following report of the principal operations at this armory during the fiscal year ending June 30, 1894.

NEW SHOPS.

The additions to these shops, referred to in the report of principal operations at the armory during the year ending June 30, 1893, were completed during the past fall.

On each floor of the machine and filing shop, and of the carpenter and stocking shop, is a water-closet, one or more washing tanks for the workmen, and kettles for hot soda water for washing work. These buildings have been wired throughout for electric light, and two dynamos for the exclusive use of these shops are about to be placed in the engine room.

The stocking shop and the carpenter shop have been fitted with a system of exhaust pipes, connected with a double fan located in the basement. This fan is 62 inches in height and requires 35 horse power to operate it; a pipe 20 inches in diameter from the carpenter shop enters on one side and a second pipe of same size from the stocking shop enters the opposite side; the outlet pipe is 28 inches in diameter and is laid under ground, in a wooden box, 320 feet to a brick chamber built without the south door of the boiler room; into this receptacle, all the shavings, chips, and dust are driven and are removed from time to time for consumption under the boilers.

Where practicable, each machine is provided with a hood about its cutters and a pipe leading into the main exhaust pipe running the length of the building. "Sweep-ups" are placed at convenient points, and in the stocking shop ventilating pipes are placed over the "stockers'" benches to draw off the fine dust from the walnut and to more thoroughly ventilate the room. The system works admirably and keeps these two shops most comfortable.

The polishing room of the filing shop is also provided with a single exhaust fan, 52 inches high, consuming 8 horse power, placed in the basement under that room; this fan is connected with a pipe running around the room immediately behind the polishing wheels, and over

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each of the latter a "hood" projects from the pipe. The discharge pipe from the fan extends over a tank of water on the outside of the building, and into this the emery is driven.

A small exhaust fan and pipes have been placed also in the browning room for the benefit of the wheels used there.

The transfer of the machinery from the old shops was carried on during the year as was found most advantageous without interfering with the work in hand.

The room at the north end of the filing shop, fitted as an extension to the milling shop, was in operation in October.

The stocking shop was put into operation in January, and the carpenter shop about the same time.

The filing shop was transferred in February, and the machine shop had one set of machines started in May, but it was not till the last part of July that this shop was in full working order.

The preparation of the fixtures and tools for the new rifle made it necessary not to disorganize the old machine shop till the last. Work was suspended for twelve days on July 7, and this time was used to complete the transfer and set that entire shop in running order.

In the annealing and tempering room have been erected three case-hardening furnaces of Brown & Sharpe's pattern, one structure containing five tempering ovens and two blueing furnaces. This room will shortly be in operation.

The fitting up of the new blacksmith shop has not been completed, and will not be probably for a couple of months.

NEW QUARTERS FOR OFFICERS.

The first set of new quarters was commenced in September last, it having been decided to do the work by day labor; this house was covered in, and slating completed by December 1. On account of most unreasonable delays in obtaining the inside finish the house is not completed at this date, but should be by November.

The second set of quarters was commenced the latter part of June of this year, and at this date is covered in and the slating commenced.

To make room for this last building an old, small set of quarters was to be removed, and with your approval the rear part was torn down and the front portion was moved bodily to a site in rear of the fire engine house, and near the entrance to the stables. This house will be occupied, when fitted up, by the noncommissioned officer in charge of the stables.

MANUFACTURE OF ARMS.

Since the last annual report the alterations to and the fitting up of machines, and the manufacture of fixtures, tools, and gauges for the manufacture of the magazine rifle have progressed steadily.

All required to enable 40 rifles to be turned out per day was accomplished by June 1; but since then many changes have been found desirable, and additional tools have been needed to increase the "output;" at this date the work is organized to produce 60 arms per day, and within a few months it is thought it will be possible to advance to 80 arms per day.

In the manufacture of this new and more complicated arm than any heretofore made at the armory a reorganization of the system in vogue was believed very desirable, if not necessary, in order to perfect the work and to keep down the cost, and some radical changes and, it is hoped, improvements have been made.

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The most important changes are, first, the introduction of cheaper labor wherever possible; and, second, the substitution as far as practicable, of machine for hand work.

To accomplish what was desired it became necessary to replace two old foremen, several inspectors, and a number of old worn-out workmen.

At the forging and finishing shop has been placed an active, intelligent, willing foreman, who has had previous experience at similar work; a new spirit and new methods have been introduced into that shop, which have been of great benefit to the work and to the armory.

A young, active, and good machinist was selected as a new foreman of the filing shop; he has labored with intelligence to diminish the amount of hand filing by placing more work on rotary filers, polishing and buffing wheels, and on other machines. A change in the working of the parts in the milling shop rendered much of this more practicable.

By the method formerly followed much of the work was not milled to gauge nor were the cuts smooth; as a result, the pieces had to be filed to the required size and finish, and much drawfiling was necessary.

The changes in the milling shop have been:

First. The introduction, so far, of some 30 boys and young men, who are paid from 75 cents to $1.50 per day, according to the nature of the work on which engaged. Of these, the lower grade remove the burs from the work, wash the work, and carry it back and forth from the inspecting room, enabling the highest-priced men to remain more constantly at their machines; the higher grade operate milling machines, their tools being kept in order by a few selected men.

Second. The more general use of double fixtures upon milling machines, so that two pieces instead of one may be worked at the same time on one machine.

Third. Obliging all finishing cuts to be taken smooth and down to exact gauge. This requires the tools to be kept sharp and the workmen to give greater care and attention.

In accomplishing this, new milling machines with an overhanging arm for supporting the outer end of the more delicate tools have been procured, and on some pieces both roughing and finishing cuts are taken.

Changes in the fixtures and tools and in the order of making the cuts are still being made almost daily, and cheaper labor being substituted wherever it is deemed practicable.

So far piece prices have been placed upon but few of the operations, as the tools are not yet in such thorough running order as to permit this to be done with sufficient accuracy.

The difficulties experienced for some time in the drilling of the barrel have deen skillfully overcome, and now but very few pieces are lost on this account.

Up to this date 2,951 magazine rifles have been fabricated, but none have been issued toward the arming of any one regiment. Several causes have delayed this since the supposed completion of the rifles: A sufficient number of bayonet scabbards have not been made; it was found necessary first to change the front sight and then the leaf of the rear sight; as the brass head to the ramrod was unsightly and bent easily, a ramrod forged in one piece has been substituted; and, finally, when it was believed that the arms were ready for issue, it was found that rust had appeared in the chamber. All these difficulties have been remedied, and as sufficient scabbards will soon be completed there should be no further delay in issuing the arms as fabricated.

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Experience has not yet developed all the difficulties that may have to be considered with smokeless powders; the formation of rust in the chamber and about the striker when gas escapes through the primer has to be looked for.

Each arm is fired at the armory 5 rounds, and if it be then cleaned imperfectly rust soon forms, but when not cleaned at all it either does not rust or all that does form is readily removed with the powder residue some time afterwards.

Sperm oil does not remove all the residue, and soda water is now being used, after which the bore is coated with cosmoline before the arm is packed.

A feature of the new arm, which was under consideration for some time, was the amount of head space for the cartridge.

With the Frankford cartridge, using a copper primer, it appeared necessary that the head should be well supported, and a space of 0.06″ was found at the armory to be most suitable and to prevent generally the piercing of the primer by the striker. As this limit was not considered practicable at Frankford Arsenal, the head space has, by your order, been fixed at 0.062″ minimum, 0.064″ maximum; this, it is found, allows many cases of piercing with the copper primer, but works well with the new cartridge using a brass primer; still, with this latter there exists the defect of escaping gas about the primer pocket, which erodes the face of the bolt or enters the striker orifice and corrodes the parts within the bolt when much gas escapes.

No erosion so far produced in the face of the bolt has been found to render that part unserviceable. To enable this surface to resist better the erosive action, when the bolt is casehardened, a small piece of potassium cyanide is placed in the well, and thus the hardness of the front surface is much increased.

Even with the amount of fitting still found necessary the success attained in the working of a mechanism so different from that of all previous manufactures at the armory can only be regarded as extremely satisfactory. A list of the component parts of the rifle is appended hereto.

Upon the death, in June last, of Mr. S. W. Porter, the late master armorer, the Secretary of War decided that his place should not be filled. This increased the duties of the foremen, as now each is held responsible for the machines, fixtures, and tools in his shop, and for their adaptability to the work required of them. The division of responsibility which existed formerly in the shops is corrected, and the result is very satisfactory.

The officers in charge of the shops are placed upon a more correct footing, and are able to be of more assistance to the commanding officer, and to acquire a better knowledge of the work of the armory.

ARMS UNDER CONTRACT.

A second contract for Colt's double-action revolvers, caliber .38, army, model 1892, was made by the Department with the Colt's Patent Fire Arms Manufacturing Company on January 4, 1893; the 3,000 arms under this contract were all inspected by the Department, and were delivered at this armory by December 31, 1893.

The method heretofore followed in the inspection of such arms has, it is thought, required too much of the Department. An employé of the armory has been placed at the factory, and been present daily as subinspector and has been performing duties which should belong to

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the manufacturer. This subinspector has constantly been called upon to examine and reject work which should not have been presented, but should have been thrown out by the contractor.

The attention of the contractor has been called to this, and with the present contract, the third that has been made for caliber .38 revolvers, a different course is being followed; the contractors with perfect willingness having arranged to have the components inspected more thoroughly before being submitted to the Department inspector. The proper course to be followed in such cases still deserves consideration by the Department.

BAYONET SCABBARD.

After some delay in the preparation and submission of samples of a bayonet scabbard for the magazine rifle, a pattern was approved by you and the manufacture ordered.

The scabbard adopted has a body of steel, with mouthpiece and two springs, between which the bayonet is held; a hook of steel, riveted to a boss upon the body, serves to attach the scabbard to the belt.

On account of the weight of this scabbard, 7½ ounces, you directed that experiments should be made with aluminum as a material for the construction.

The Pittsburg Reduction Company presented several samples of sheet aluminum, alloyed with other metals to obtain stiffness. From one of these, scabbard bodies were successfully formed with the same machines as are employed in the manufacture of the steel scabbard. At this point the success terminated, as up to the present all methods tried to produce a firm, neat, and practicable union of the folded edges have failed. Numerous solders exist which can be used on this metal by means of the ordinary soldering iron, but that method is not suited to this particular work.

Another company is now experimenting with the construction of a scabbard with folded edges. This gives a very attractive looking scabbard, but so far one not possessing sufficient stiffness.

The Carbo-Alumina Metal Company of St. Louis has undertaken to cast a scabbard of their metal. The result as yet is not known.

Aluminum is a very attractive metal to the eye and to the hand, but its utility about a military firearm is a very open question. Castings have been obtained for certain parts of the magazine rifle, but all so far have proved useless.

STEEL FOR GUN BARRELS.

The test of samples of steel for rifle barrels was continued during the year, and of those numbered 40 and 41 in the subjoined table 50,000 pounds of each were purchased for use. Little difference has been found between the metals from the two manufacturers and each has been quite uniform.

The test of samples was continued after the selection of the stock for the current year in order to determine what might be available in the future.

No. 54 were ten barrels of Swedish steel sent to this country through the intervention of Capt. E. L. Zalinski, U. S. Army, referred to in first indorsement, July 20, 1893, Ordnance Office, file 3798 of 1893. Several barrels have been completed and placed in arms, and are about to be tested.

No. 56 contains, it is understood, about 4 per cent of nickel. The two barrels obtained are ready for test.

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Samples of steel tested to determine those suitable for rifle barrels, caliber .30.

No.	Date.	From whom.	Designation.	Tenacity.	Elastic limit.	Elongation.	Remarks.
	1893.			*Pounds.*	*Pounds.*	*Per cent.*	
39	Sept. 12	Spaulding, Jennings & Co.	No. 1	120,440	63,000	12.67	Turning chips hard and brittle.
40	Sept. 12	....do	No. 2	113,040	66,000	16.67	Worked well; 50,000 pounds purchased.
41	Sept. 12	Midvale Steel Co	No. 255	108,160	61,000	21	Do.
42	Sept. 12	....do	No. 8684, special	102,000	65,000	22½	Price too high for quality.
43	Sept. 20	Park Bros		105,520	51,000	19.67	Elastic limit too low.
44	Sept. 20	Howe, Brown & Co	Crucible machinery, No. 8	89,800	54,000	23.3	Properties too low.
45	Sept. 20	....do	Tool, cast steel, No. 5	122,480	54,000	10.67	Elastic limit and elongation low.
46	Sept. 20	....do	....do	120,000	53,000	7.33	
47	Sept. 20	....do	Crucible machinery, No. 8	89,360	48,000	23.33	Properties too low.
48	Sept. 20	Windsor Locks Steel Co	Red end	100,000	63,000	5.33	Metal not uniform, with hard spots.
49	Sept. 20	....do	Blue end	104,560	62,000	17.33	
50	Oct. 2	Spaulding, Jennings & Co.	1 of 8 barrels, first end	147,280	120,000	9.67	Metal treated by special process; not practicable for barrels
51	Oct. 2	....do	1 of 8 barrels, second end	146,040	117,000	9.67	
52	Oct. 2	Sanderson Steel Co	Tool steel	132,800	62,000	6.33	Can not be worked with usual tools.
53	Oct. 2	....do	Tool steel, annealed	85,200	44,000	14.33	Properties too low and can not be restored.
54	Oct. 11	Swedish	10 barrels received	113,200	80,000	14	Experimental barrels made for test.
55	Oct. 19	Midvale Steel Co	Annealed, No. 255	101,400	56,000	19.67	Worked well; elastic limit too low and treatment not practicable for barrels.
	1894.						
40′	Jan. 5	Spaulding, Jennings & Co.	Stock	107,240	94,000	21	Tested to verify stock in use (Nos. 40 and 41).
41′	Jan. 5	Midvale Steel Co	....do	109,280	65,000	18	
56	Jan. 23	Atha, Illingworth & Co	Special, barrel	106,160	70,000	21½	Properties below those represented by manufacturer; further tests to be made.
57	Mar. 3	Bethlehem Iron Co	Nickel-steel	118,000	105,000	20.33	Worked very hard and with difficulty throughout; from 5 pieces but 2 barrels were obtained.
57′	Mar. 3	....do	....do	115,680	105,000	20	
58	Mar. 3	Midvale Steel Co	No. 255, oil tempered	135,750	104,000	23	Metal hard with harder spots; impracticable for barrels as now made.
58′	Mar. 3	....do	....do	135,850	107,000	28	
59	Apr. 3	Hawkridge Bros	Manufacturer not known	110,840	64,000	17	Worked well; price too high, about same as Nos. 40 and 41.
60	Aug. 10	Prosser & Son	Krupp's	104,400	59,000	18.67	Harder than stock in use, and in rifling not smooth; not superior to stock in use, and costs more.

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INVENTIONS FOR MAGAZINE SMALL ARMS.

The papers and designs relating to magazine arms submitted by inventors have, as received during the year, been examined and reported upon in accordance with your instructions of January 3, 1893.

The following are the principal papers that have been received up to this date, the action on each noted:

December 19, 1893.—John Frick, of Laramie, Wyo., incloses drawing of patent No. 428597, granted him for breech-loading firearm.

Referred from Ordnance Office: "A letter from the within writer was received at this office, and on October 18 a copy of the circular letter of January 2, 1893, was sent, with instructions to apply to the commanding officer Springfield Armory for further information."

January 3, 1894.—Returned to the Chief of Ordnance "with report that Mr. Frick on November 16, 1893, sent to this office a copy of his patent specification of a firearm. A duplicate of this paper was called for, which is the one referred to within. The description of this arm has been examined and is found to relate to a simple breech-loader, and therefore is not such as is now sought for military service. As a simple breech-loader it is inferior to other known arms of the kind. Mr. Frick has been advised of the submission of this report."

January 16, 1894.—George Edwards, of Berkeley, Cal., incloses drawing and description of repeating arm designed by him, to meet defects in the Krag-Jorgensen magazine arm.

Referred from Ordnance Office: "Referred for report."

February 12, 1894.—Returned to the Chief of Ordnance "with report that careful attention has been given to the changes proposed by Mr. Edwards, and it is believed that none of the features possess sufficient merit to justify further consideration. Some of the parts designed are not new and have already been condemned by a recent board on magazine arms. Mr. Edwards has assumed defects which, so far, have not been found to exist, and should they develop hereafter means to overcome them can then be sought. The proposed arm is more complicated than the magazine rifle, model 1892."

August 19, 1894.—J. W. Mullins, of Fariston, Ky., has a gun with magazine more simple than last one tested by the War Department. Requests it examined by persons who have no interest in any other gun.

Referred from Ordnance Office: "Referred for remark."

August 27, 1894.—Returned to the Chief of Ordnance "with report that Mr. Mullins' inventions in the line of firearms have several times been considered at this armory, and report made upon them. So far his designs have possessed no merit; whether or not the arm to which he refers within may be an improvement upon those that have preceded it can not be judged from his statement."

September 19, 1894.—J. W. Mullins, of Fariston, Ky., states difference between his magazine gun and those previously sent.

Referred from Ordnance Office: "The Department has previously informed Mr. Mullins that it deemed a further trial of his magazine arms unnecessary. In view, however, of the changes in design stated, he is requested to report whether he deems them of such merit as to render a further trial of the arm advisable."

September 20, 1894.—Returned to the Chief of Ordnance "with report that no intelligent opinion can be given upon the merits of the arm from the remarks within, and that Mr. Mullins should furnish a drawing or model of his new design. Judging from what has gone before, Mr.

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Mullins has little conception of what constitutes a desirable magazine arm, or what may be worthy of trial."

Respectfully, your obedient servant,

A. MORDECAI,
Colonel, Ordnance Department U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

Component parts of United States magazine rifle, caliber .30, model 1892.

Barrel.	Firing pin.	Rear-sight base screw, front.
Bayonet blade.	Follower.	Rear-sight base screw, rear.
Bayonet catch.	Follower pin.	Rear-sight base spring.
Bayonet-catch nut.	Front sight.	Rear-sight joint pin.
Bayonet-catch spring.	Front-sight pin.	Rear-sight leaf.
Bayonet gripe, body, right.	Front-sight stud.	Rear-sight slide.
Bayonet gripe, body, left.	Gate.	Rear-sight slide cap.
Bayonet-gripe rivets (2).	Guard.	Rear-sight slide-cap screw.
Bayonet-gripe washers (4).	Guard screw, front.	Rear-sight slide catch.
Bayonet guard.	Guard screw, rear.	Rear-sight slide-catch spring.
Bayonet pommel	Guide lip.	Receiver.
Bolt.	Guide-lip pin.	Safety lock.
Butt plate.	Hand guard.	Safety-lock pin.
Butt-plate screw, large.	Hand-guard rivets, front (2).	Sear.
Butt-plate screw, small.	Hand-guard rivets, rear (2).	Sear spring.
Butt swivel.	Hand-guard spring, front.	Securing stud.
Butt-swivel pin.	Hand-guard spring, rear.	Securing-stud rivet.
Butt-swivel plate.	Hinge bar.	Side plate.
Butt-swivel plate screws (2).	Hinge-bar head.	Side-plate screw.
Carrier.	Lower band.	Sleeve.
Cocking piece.	Lower-band pin.	Stacking swivel.
Cut-off.	Lower-band swivel.	Stacking-swivel screw.
Cut-off spring.	Lower-band swivel screw.	Stock.
Ejector.	Magazine spring.	Striker.
Ejector pin.	Mainspring.	Trigger.
Extractor.	Ramrod.	Trigger pin.
Extractor spring.	Ramrod stop.	Upper band.
Extractor screw.	Rear-sight base.	Upper-band screw.

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APPENDIX 3.

PROGRESS REPORT ON THE MANUFACTURE OF .30-CALIBRE AMMUNITION AT THE FRANKFORD ARSENAL, PA.

(1 plate.)

FRANKFORD ARSENAL,
Philadelphia, Pa., June 30, 1894.

SIR: In obedience to your instructions, I have the honor to respectfully forward a condensed report of progress made in the development and manufacture of the .30-caliber ammunition during the last fiscal year.

The plant for the production of the new ammunition has been gradually developed during the year, and it is proposed to start the new fiscal year with an output, in connection with other cartridge work, of 8,000 .30-caliber cartridges per day. The processes of manufacture are still in a state of transition. Old machines have been modified and new ones constructed, but these are not considered as having yet reached the perfected stage, and new automatic machines will doubtless yet be devised to diminish the considerable amount of hand labor now necessary.

The following experimental ammunition was manufactured and issued during the year to the Springfield Armory:

Date.	Amount.	How loaded.	Powder.	Charge.	Bullet.
1893.				*Grains.*	
October 18	2,000	By hand	Old Wetteren	37	German-silver jackets.
December 9	1,000	....do	Troisdorf	34	Do.
1894.					
January 30	2,000	By machine	....do	35.3	Do.
March 28 and 29	3,000	....do	....do	35.3	Do.

In loading by machine December 16, 1893, the following results were obtained with two prominent representatives of the flake powders:

	Troisdorf.	New Wetteren.
Number of charges	50	50
Heaviest charge.....grains	35.9	36.5
Lightest charge.....do	35.3	35.8
Average charge.....do	35.77	36.094
Extreme variation.....do	.6	.7
Mean variation.....do	.3	.35

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In velocity tests of ammunition loaded by machine on June 15, with Peyton powder, the following resulted:

Time.	Velocity.	Extreme variation.	Mean variation.
	Ft. secs.	*Ft. secs.*	*Ft. secs.*
1 p. m	1963. 8	36	9. 36
3 p. m	1959. 8	12	3. 40
3 p. m	1960	18	5. 2

These results were exceptionally favorable, as it is difficult with any of the smokeless powders to regulate the velocity so as to obtain approximately the standard of 1,960 foot-seconds from day to day, and even from hour to hour constant and sometimes considerable changes have been found to take place.

Regular manufacture, using an American smokeless powder (Peyton), commenced on May 7, and up to this date 196,668 rounds of this ammunition have been issued or placed in store.

The following considerations regarding the components may prove of interest:

CASE.

Certain slight modifications have been made in the case, as follows:

(1) The rim of the head has been turned to remove a slight burring incident to its forming,* and which injured somewhat the appearance of the case.

(2) The discovery was made that cracks occasionally occurred at the bottom of the pocket in manufacture, these not sufficiently pronounced to be discovered in the testing machine, but still allowing the bottom to be bent down or blown in by a strong primer. It was thought that the metal was too much fatigued by the entire formation of the pocket without annealing, and to overcome this difficulty the first operation of shaping the pocket was carried back to take place after the fifth draw. The metal at the head then has the benefit of an annealing before the second operation of forming the pocket.

(3) The limits as to thickness of head have been changed from 0.058″—0.065″ to 0.060″—0.065″.

(4) The form of the pocket has been slightly changed (Figs. 1 and 2) for reasons given under the heading of "Primer."

Experiments have been made during the year with aluminum bronze as a metal for the case, but these have not yet been concluded.

PRIMER.

At the expiration of the last official year it was hoped that a satisfactory solution of this rather troublesome problem had been arrived at in a primer powerful enough to ignite efficiently the most obdurate smokeless powder. This contained a pellet, weighing four-tenths of a grain, of the following composition:

Fulminate of mercury	45. 1
Chlorate of potash	25. 8
Antimony	12. 9
Glass	16. 1

Early this year experiments were recommenced with a second lot of these primers, when it soon became evident that the conditions of the

*This burring developed in instances where the pocket shaping was carried back to the fifth draw. J. P. F.

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original success had been varied from in some unaccountable way. Other lots were prepared and tested with results of uniform failure to explode satisfactorily charges of Troisdorf powder, which had been selected as being the most difficult to ignite.

Without arriving at any entirely satisfactory explanation of the difficulty, the composition was finally abandoned as unreliable.

The following composition was then experimented with, this having previously given good results:

Fulminate of mercury	61.5
Chlorate of potash	19.0
Glass	18.0
Mealed powder	1.5

A four-tenths pellet of this composition proved of sufficient strength to ignite satisfactorily the Troisdorf and other obdurate powders, and these primers, under the designation of E/4, have been used extensively for experimental purposes up to the present time. It was believed that this would serve for use with any smokeless powder that might be adopted. At the same time the fear was entertained and expressed to the Department that on the receipt here of the new magazine rifles the primer question might be again thrown back into the experimental stage. Results have proved that these fears were well founded, as, soon after the receipt of the new arms, the fact was developed that the *copper* primer was not equal to the severe conditions imposed by the new firing pin, since, due to the softness of this metal, it offered but slight resistance to the "punching" action of the "striker" point. After due consideration of the conditions of head space, thickness of cartridge head, etc., it was determined to abandon copper as being unsuited for a primer metal under the existing circumstances. Brass primers were then procured for temporary use and experiment, and efforts immediately initiated to procure a brass or other metal which, while offering more resistance to punching, would still possess ductility sufficient to draw well, give good obturation, and not crack either from the pressure incident to the insertion of the anvil or from the more sudden action of the primer explosion. In the use of brass primers difficulties have arisen from imperfect obturation and from bursting at the "shoulder." The escape of gas at this point is serious in its effect on the face of the bolt, rapidly pitting and scoring the surface. This escape may be due either to a fine crack in the side of the primer, which the gas quickly finds and follows up to pass out at the shoulder, or it may be through a minute flaw or perforation which existed originally, or is produced in the abrupt bending of the metal or during the extension it undergoes when the primer settles back to its support. To reduce the latter action, it was found necessary to change the form of the pocket, as illustrated in Pl. I, Figs. 1 and 2. The old form permitted an expansion and flattening of the head of the primer, taking shape as represented, and the brass was not ductile enough to withstand this action.

It is evident that a metal which yields but little before rupture under the strong and sudden pressure of a primer explosion is not suited for present primer purposes.

It is now thought that a satisfactory metal for primers will be found in an alloy between the primer copper and the brass heretofore used, a metal which will combine to a sufficient degree the ductility and toughness of the copper with the resistance to "punching" offered by the brass. Tests are also being made with a special aluminum bronze adapted to primer requirements.

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Strength of primers.—While the E/4 is a powerful primer and has proved extremely useful in tests with obdurate powders, difficulties have been met with in providing for so large a pellet in such limited space, in the burning of many in loading these primers by machine, and in loading by hand, as it is difficult in many cases to force them below the plane of the head without causing explosion. Experiments have therefore been inaugurated looking toward a reduction in the primer pellet to 0.35 of a grain.

The E composition is also believed to be, from its large proportion of fulminate, too sudden in its action for any brass high in quality, and, while searching for an improvement in the metal, efforts are also being made to find a composition which will not have so great a tendency to wreck the primer by its own action.

The following composition is of the nature required, but is extremely sensitive to friction, and every precaution has to be exercised in working even in the wet condition:

Fulminate of mercury	31
Chlorate of potash	38
Antimony sulphide	31

In mixing the above composition wet it has been found that, probably due to the powerful action of the chloric acid on the sulphide of antimony, the temperature of the paste has been raised considerably—in one instance to 113° F.

It has become evident that a difference in the strength of primers may exercise considerable influence on the velocities obtained, though this is much more marked in some cases than others. It is probable that this difference is slight in cases where either of two varying primers is strong enough to thoroughly ignite the powder without any suspicion of a hang fire.

The following is a marked case of variation in velocity due to variation in the strength of primers:

Charge, 36 grains New Wetteren smokeless powder.

Rounds.	Primer.	Muzzle velocity.	Maximum velocity.	Minimum velocity.	Extreme variation.	Mean variation.
		Ft. secs.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
20	0.25 grain pellet	1,894	1,932	1,851	81	20.6
20	0.50 grain pellet	2,010	2,050	1,970	80	17.6

JACKET METAL.

During the past year bullets with German-silver jackets have been used to a considerable extent for experimental purposes, but for the regular manufacture the cupro-nickeled steel jackets have alone been used. Both finished jackets and sheet metal for their manufacture have been obtained from foreign sources. This metal is found to overcome the objections incident to ordinary cupro-nickel jackets, of stripping with high velocities and yielding to the upsetting of the lead core on penetrating any medium of considerable resistance. The mean velocity and accuracy are also found to be slightly superior with the cupro-nickeled steel.

Excellent results have recently been obtained here with a sample of cupro-nickel manufactured in this country, but it failed to quite attain the standard of the cupro-nickeled steel as regards accuracy, velocity, or penetration. Experiments will still be continued with jacket metals and effort made to find for this purpose some suitable metal which can

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be obtained in our home market. As a rule the cupro-nickel, when compared with cupro-nickeled steel, is easier to work, gives less wear on the dies and punches, does not require the labor and expense of annealing, and gives a finished bullet somewhat superior in appearance. The first cost of cupro-nickel is greater, but taking into account the difference in working, and the fact that its scrap is valuable, while that from the other metal is worthless, it is probable that the two metals are upon about an even footing as regards expense—that is, so long as a single firm can alone supply the cupro-nickeled steel.

With the purchased jackets it was found necessary to ream out slightly an interior shoulder which existed to a greater or less degree near the junction of the head and cylinder (*a*, Fig. 3). This shoulder was reduced to give closer approximation to uniformity in weight of the finished bullets. As received, the jackets themselves were found to vary in weight from 36 to 39 grains, a variation which could not be permitted even in the finished bullets.

BLANK CARTRIDGE.

A model for the blank cartridge is under consideration, this having been adapted from a description in Revue Militaire de l'Etranger for August, 1893, but accredited therein to the Belgique Militaire.

The case is sufficiently firm not to be injured by the working of the magazine, and is not to throw any kind of dummy projectile. It is made of the ordinary cartridge brass and has the form of the ball cartridge, the case being prolonged and made to terminate in the shape of the absent projectile, the point being formed by the folding in of three serrations (*See* Figs. 4 and 5.)

At the moment of firing, the projections open out to permit the passage of the gases and to effect the obturation.

The cartridge is extracted easily from the chamber and can doubtless be recharged a number of times.

Owing to the difficulty of igniting small charges of smokeless powder in a case having such increased capacity, the great trouble in using wads below the upper shoulder, and the danger from using any pasteboard or other case to diminish the powder space, black powder will probably be used, at least for the present.

GALLERY CASE.

A model for a special gallery case has been under consideration. It is made from a solid rod of brass and corresponds in its exterior dimensions with the regular case. A cylindrical space is bored out for the reduced charge of black powder and the round ball of hardened lead. This case has been loaded and fired a large number of times and requires no resizing.

Very respectfully,

CHARLES H. CLARK,
Captain of Ordnance.

The COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 5, 1894.

Approved and respectfully forwarded to the Chief of Ordnance U. S. Army.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

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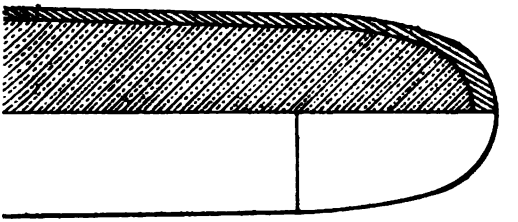
PLATE I



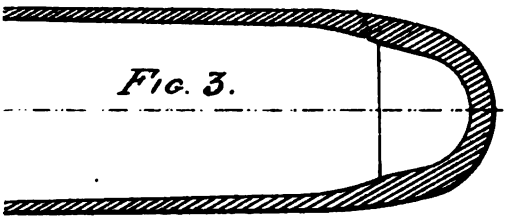
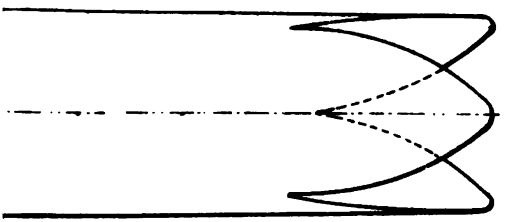


Fig. 3.



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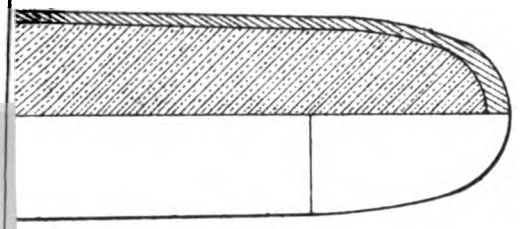


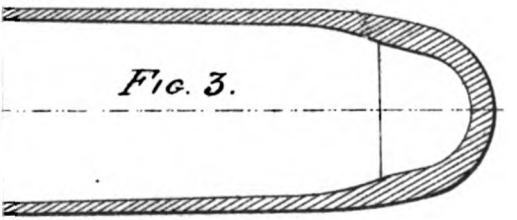
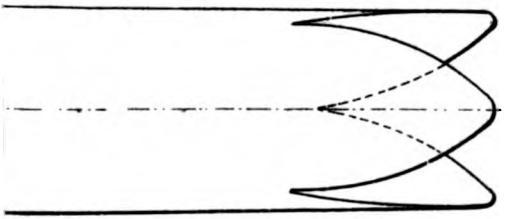


Fig. 3.



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APPENDIX 4

REPORTS UPON TESTS OF .30-CALIBER LUBRICATED AND NONLUBRICATED BULLETS AND MATERIALS FOR BULLET COVERING.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 29, 1892.

SIR: I have the honor to submit the following report of experiments made by your direction to determine the effect of cannelure lubrication upon the accuracy and velocity of small-caliber bullets. The effect of cannelure lubrication as regards prevention of wear of barrel was also considered.

ARMS.

The lubricated ammunition was fired in Springfield experimental .30-caliber rifle "N." This rifle had never been fired before.

The nonlubricated ammunition was fired in Springfield experimental .30-caliber rifle "O." This rifle had never been fired before. Both rifles were carefully star gauged before firing.

CHARGE.

All the cartridges fired were loaded with a charge of 37 grains Wetteren powder sieved between +" .08 and —" .06 (rejecting all grains that did not pass through a sieve having holes of " .08 and all that passed through a sieve having holes " .06 in diameter).

BULLETS AND LUBRICATION.

The nonlubricated bullet was of hard lead with German silver* jacket " .015 thick without cannelures. The lubricated bullet was of hard lead with German silver jacket ".015 thick, cannelured and lubricated in the cannelures. The weight of both bullets was the same—230 grains.

CONDITIONS OF FIRING.

An equal number of shots were fired for velocity and accuracy from each gun. The guns were cleaned after each 10 shots. The velocity records were made by series of 50 shots, and the accuracy was deter-

*Two different varieties of German silver were tried, one the French bullet jacket composition, 4 parts copper and 1 nickel, and the other a special-mixture—composition not furnished by the manufacturers. No difference was noticed in their behavior.

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mined by firing 5 targets of 10 shots each for a series. The test was much delayed by other more pressing experiments taking precedence of it.

* * * * * * *

The results are tabulated as follows:

Velocity at 53 feet from muzzle, series of 50 shots each.

Number of series.	Mean velocity.		Mean variation.		Extreme variation.	
	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.
	Ft. secs.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
1	1,982.10	1,973.20	18	20.84	70	125
2	1,974.90	1,978.12	17.30	18.30	82	108
3	1,974.16	1,978.32	16.58	20.24	106	93
4	1,952.10	1,951.60	21.38	20.88	106	122
5	1,950.30	1,970.50	16.84	16.60	110	81
6	1,959.24	1,966.18	19.90	20.42	122	112
7	1,964.50	1,956.50	15.40	25.98	74	128
8	1,966.50	1,968.40	16.92	20.60	78	95
9	1,957.16	1,966.02	15.52	17.26	74	98
10	1,983.72	1,972.52	16.82	21.88	80	79
Mean of 500 rounds	1,966.45	1,968.13	16.4	20.3	.....	.....

	Ammunition.	
	Lubricated.	Nonlubricated.
	Ft. secs.	*Ft. secs.*
Greatest velocity obtained	2,037	2,033
Least velocity obtained	1,900	1,896
Extreme variation	137	137

From the above it appears that the cannelured and lubricated bullets give no increase of velocity, though the mean variation with these was less in the trials than with the other variety.

Accuracy at 500 yards, series of 5 targets of 10 shots each.

Number of series.	Mean radius circle of shots.		Mean vertical deviation.	
	Lubricated.	Nonlubricated.	Lubricated.	Nonlubricated.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1	1.214	1.194	1.044	1.008
2	.880	1.008	.727	.846
3	1.036	1.066	.839	.803
4	1.440	1.232	1.215	.932
5	1.270	1.230	1.125	.967
6	1.146	1.146	.895	.914
7	1.212	1.156	.871	.764
8	1.378	1.402	1.210	1.180
9	1.406	1.386	1.288	1.104
10	1.336	1.484	1.234	1.333
Mean of 50 targets of 10 shots each	1.231	1.230	1.04	.98
Best target of 10 shots	.60	.73	.46	.55
Worst target of 10 shots	1.89	2.04	1.73	1.83

The above results show no difference as to accuracy between the two kinds of ammunition.

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For the sake of comparison 56 targets (the targets were fired in series of 8) made consecutively with the last lot of service .45-caliber rifle ammunition manufactured were taken from the records, as follows:

Number of targets, 10 shots each	56
Mean radius circle of shots, foot	.697
Mean vertical deviation, foot	.482

The .30-caliber targets are far inferior to the .45-caliber ones. This is due, however, not to the inferiority in accuracy of the .30-caliber ammunition, but probably to the vibration of the rifle barrel in the fixed rest. To show this some of the same ammunition used in the experiment under consideration was fired in the barrel used in taking pressures, which is very heavy, weighing more than 20 pounds.

The following are the results obtained:

	Number of shots.	Radius circle of shots.	Mean vertical deviation.
		Foot.	*Foot.*
Cannelured and lubricated bullet	10	0.50	0.475
Uncannelured nonlubricated bullet	10	.41	.340

This heavy gun is the only small caliber arm with which for a given number of targets accuracy has been obtained equal or superior to the standard accuracy for the .45 caliber arm and ammunition. About a year ago a number of targets were fired with it, using lubricated and nonlubricated ammunition, with the following result:

Lubricated ammunition.

Number of targets, 10 shots each.	Radius circle of shots.	Mean vertical deviation.
	Foot.	*Foot.*
15	0.432	0.308
Best target	.30	.22
Worst target	.68	.41

Nonlubricated ammunition.

Number of targets, 10 shots each.	Radius circle of shots.	Mean vertical deviation.
	Foot.	*Foot.*
8	0.552	0.410
Best target	.41	.340
Worst target	.77	.42

The above results seem to indicate that a very heavy barrel should be used at this post for testing the product of small caliber ammunition for accuracy.

Rifles N and O were both carefully star gauged on the conclusion of the firing, Mr. Wernle and myself doing the gauging. We are both of the opinion that the small arms star gauge in its present form is unreliable and that its readings can not be depended on much below 0.002". The greatest difference between readings of gauge before and after firing is 0.0011" at 28 and 26 inches from muzzle in gun O, used for uncannelured and nonlubricated ammunition.

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Up to date, including all sighting shots, etc., there have been fired from each of the above rifles 1,034 rounds.

Respectfully, etc.,

J. W. BENÉT,
First Lieutenant Ordnance Department,
In charge Ballistic Division.

COMMANDING OFFICER FRANKFORD ARSENAL.

NOTE.—The pressures due to the charge of 37 grains of the sieved Wetteren powder used in these experiments, as determined by concurrent tests in .30 caliber pressure rifle, were:

November 16, 1892, 8 rounds, pressures between 38,500 and 45,000 pounds, mean, 41,200 pounds per square inch.

November 17, 1892, 10 rounds, pressures between 40,000 and 44,000 pounds, mean, 41,900 pounds per square inch.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 31, 1892.

Respectfully forwarded to the Chief of Ordnance, U. S. Army.

This progress report expresses the results of tests made in accordance with the instructions of the Chief of Ordnance of June 17, 1892, twelfth indorsement, Ordnance Office, file No. 1217 C, 1892.

After the experiments directed to be made at this arsenal for Dr. Louis A. La Garde, Medical Department U. S. Army, have been completed, the tests herein inaugurated will be continued.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

FRANKFORD ARSENAL, PA., *September 8, 1893.*

SIR: I have the honor to submit the following report of experiments made by your direction to determine the effect of cannelure lubrication upon the accuracy and velocity of small caliber bullets. The effect of cannelure lubrication as regards prevention of wear of barrel was also considered.

These experiments were in continuation of those reported upon by me. December 29, 1892.

ARMS.

The lubricated ammunition was fired in Springfield experimental .30 caliber rifle N. This rifle had been fired 1,054 rounds in the previous experiments.

The nonlubricated ammunition was fired in Springfield experimental .30 caliber rifle O. This rifle had been fired 1,054 rounds in the previous experiments. Thirty-five targets of 10 shots each, of each kind of ammunition, were fired from a heavy barrel weighing 41 pounds, in order to obtain a comparison with the inaccuracies caused by the vibration, buckling, etc., of the ordinary rifle eliminated. As usual the fixed rest was employed in the firing for accuracy.

The length rifling and interior dimension of bore was the same as for the experimental Springfield rifles used.

POWDER CHARGE.

All the cartridges fired were loaded with a charge of 37 grains Wetteren powder sieved between + 0.08″ and —0.06″ (rejecting all grains that did not pass through a sieve having holes of 0.08″ and all that passed through a sieve having holes 0.06″ in diameter).

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BULLETS AND LUBRICATION.

The nonlubricated bullet was of hard lead with German-silver jacket 0.015" thick, without cannelures. The lubricated bullet was of hard lead with German-silver jacket 0.015" thick, cannelured and lubricated in the cannelures. The weight of both bullets was the same, 220 grains.

The preceding experiments were made with 230-grain bullets, but none of them being on hand it was necessary to use the lighter service bullet.

CONDITIONS OF FIRING.

An equal number of shots were fired for velocity and accuracy from each gun. The guns were cleaned after each 10 shots. The velocity records were made by series of 50 shots and the accuracy was determined by firing 5 targets of 10 shots each for a series.

The tests had to be carried on from time to time when more urgent experiments did not interfere.

* * * * * * *

Summary.

[Velocity at 53 feet from muzzle. Series of 50 shots.]

Number.	Lubricated ammunition.		Nonlubricated ammunition.	
	Mean velocity.	Mean variation in velocity.	Mean velocity.	Mean variation in velocity.
1	1,988	17.9	2,013	16.0
2	1,998	21.8	2,010	18.4
3	1,982	20.2	2,013	20.2
4	1,990	21.9	1,999	13.8
5	1,999	18.7	2,000	17.5
6	1,987	22.1	2,001	14.6
7	2,002	17.2	1,997	15.5
8	1,985	20.9	1,979	16.8
9	1,985	18.3	1,990	16.4
10	1,987	21.3	1,975	19.2
Mean of 500 shots	1,990	20	1,997	16.8

[Accuracy at 500 yards. Heavy barrel.]

Series.	Lubricated ammunition.			Nonlubricated ammunition.		
	Number of targets in series.	Mean radius circle of shots.	Mean vertical deviation.	Number of targets in series.	Mean radius circle of shots.	Mean vertical deviation.
		Feet.	*Feet.*		*Feet.*	*Feet.*
1	5	0.398	0.30	5	0.366	0.29
2	5	.412	.28	5	.474	.33
3	5	.320	.24	5	.368	.25
4	20	.305	.22	20	.319	.21
Mean of 35 targets		.358	.26		.381	.27

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[Accuracy at 500 yards. Springfield experimental barrels O. N. Series of 5 targets.]

Number.	Lubricated ammunition.		Nonlubricated ammunition.	
	Radius circle of shots.	Mean vertical deviation.	Radius circle of shots.	Mean vertical deviation.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1	1.53	1.40	1.36	1.13
2	1.43	1.25	1.33	1.13
3	1.10	.91	1.07	.82
4	1.33	1.19	1.04	.72
5	1.14	0.98	.91	.65
6	1.22	1.12	1.16	.94
7	.97	.80	.91	.68
8	1.03	.88	.96	.77
9	1.12	1.00	1.01	.87
10	.99	.87	.94	.76
Mean of 50 targets	1.18	1.04	1.06	.84

Cartridges which were fired in the pressure barrel gave the following results. These cartridges were identical as to charge and bullet with those used in the experiments:

Number of shots		9
Mean velocity at 53 feet from muzzle	foot-seconds..	1.962
Mean pressure	pounds per square inch..	38,500
Mean variation in velocity	foot-seconds..	19.6

REMARKS.

With the lubricated ammunition the highest mean velocity of any series was 2,002 foot-seconds and the lowest 1,982 foot-seconds, a difference of only 20 foot-seconds, and no falling off in velocity was indicated.

The mean velocity for the 500 shots was less than with the nonlubricated ammunition and the mean variation in velocity was greater. The cause of this is not apparent.

With the nonlubricated ammunition the highest mean velocity of any series was 2,013 and the lowest 1,975 foot-seconds, a difference of 38 foot-seconds, and a slight falling off in velocity does seem to be indicated.

The uniformity of velocity in every series was superior to that of the lubricated ammunition. As regards accuracy, with the heavy barrel, the results are slightly in favor of the lubricated ammunition; with the ordinary rifle, the reverse is the case.

On the whole the experiments confirm the previous ones and indicate that lubrication in the cannelures gives no advantage as regards velocity.

Both guns were star gauged.

In a previous report I expressed my opinion as to the untrustworthiness of this star gauge. Gun N, used with the lubricated ammunition, showed an increase of diameter between lands in places, never exceeding 0.0015 inch, while the bore, through a space of 8 inches from 29 to 21 inches from the muzzle, showed a decrease of diameter amounting in some measurements to as much as 0.01 inch. This was found to be caused by the deposition of metal presumably from the bullet jacket which could not be removed by the ordinary methods of cleaning but was scraped off with a wire after some difficulty.

No deposit of this kind was found in the bore of the gun used for nonlubricated ammunition, in which a slight increase of diameter

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between lands was indicated throughout the bore not exceeding 0.0015 inch.

Respectfully, etc.,

J. W. BENÉT,
First Lieutenant, Ordnance Department, U. S. Army.

COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 13, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army, in connection with Lieut. J. W. Benét's report of December 29, 1892, forwarded December 31, 1892, Ordnance Office file No. 68, 1893, on this same subject.

It is my intention to further test these rifles O and N with the non-lubricated uncannelured bullets, the one with the nickeled steel jacketed bullets, and the other with the German silver jackets. It is thought that in this manner the comparative wear and tear on the barrels will be more fully established than by commencing the tests with the nickeled steel jackets in entirely new barrels, as wear after 2,000 rounds will probably be more pronounced. Other tests with the nickeled steel jackets will be prosecuted systematically with new barrels as soon as practicable.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 9, 1894.

SIR: The following is respectfully submitted as record of tests continued, in accordance with your instructions, with Springfield experimental rifles N and O, which had previously been fired 2,078 and 2,055 rounds, respectively.

The ammunition was made up at the loading room with a charge of 36 grains of Wetteren powder, new. (Lot of 500 pounds received in October, 1893.) The primer with percussion pellet of 0.25 grain was used, as directed. The ammunition fired from the N rifle had the bullet with German-silver jacket; that used with the O rifle, the cupro-nickeled steel jackets taken from the lot of 15,000 received from Herman Boker & Co., in October, 1893.

The experiments were conducted at such times as permitted by other and more pressing experimental work.

In the tests for accuracy the 5 targets were fired with short intervals from 1 rifle, without cleaning, and immediately after 5 targets fired similarly with the other ammunition and rifle.

In firing for velocity, the 2 rifles with corresponding ammunition were fired on the same day, the bores being uniformly cleaned after each 20 rounds.

Thirty-five targets with each kind of ammunition were fired from the heavy accuracy barrel, this partly for fixing standards for comparison with previous experiments, and partly to furnish a reliable comparison regarding the 2 bullets used. Conclusions as to the latter have already been submitted in a previous report. For purposes of comparison and to determine questions arising in the course of the firing, extra tests were introduced with other ammunition than that described, as follows:

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Velocity:

Twenty rounds; 36 grains Wetteren powder, new; primer; 0.25-grain pellet; loaded at proof house.

Twenty rounds; 36 grains Wetteren powder, new; primer; 0.5-grain pellet; loaded at proof house.

Twenty rounds; 33 grains Leonard powder (N, fine); primer; 0.4-grain pellet.

One hundred and forty rounds; 37 grains Wetteren powder, old; primer; 0.25-grain pellet.

Accuracy:

One hundred and sixty rounds; 37 grains Wetteren powder, old; primer; 0.25-grain pellet.

In all 1,015 rounds were fired from each rifle (N and O), 35 of these being preliminary shots not recorded in the report.

* * * * * * *

Summary, heary barrel.

[Charge: 36 grains new Wetteren powder. Primer, E 0.25.]

ACCURACY AT 500 YARDS.

Date.	Number of targets.	Radius circle of shots.		Mean vertical deviation.	
		G. S. jackets.	C. N. S. jackets.	G. S. jackets.	C. N. S. jackets.
1893.					
November 1	10	0.531	0.387	0.4110	0.2740
November 9	5	.540	.402	.447	.326
November 10	20	.562	.494	.4842	.4007
Mean	35	.550	.450	.458	.3538

VELOCITY AT 53 FEET 11½ INCHES.

Date.	Number of shots.	German-silver jacketed bullets.			Cupro-nickled steel jacketed bullets.		
		Mean velocity.	Extreme variation.	Mean variation.	Mean velocity.	Extreme variation.	Mean variation.
1893.		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
November 4	10	1,882	100	25.2	1,913	68	13.2
November 11	50	1,888	198	33.56	1,900.5	174	21.9
Mean	60	1,887	181.66	32.16	1,902.6	156.3	20.45

Summary, N and O rifles.

[Charge: 36 grains new Wetteren powder. Primer, E 0.25; loaded at shops.]

VELOCITY AT 53 FEET.

Date.	Number of shots.	German-silver jacketed bullets, N rifle.			Cupro-nickled steel jacketed bullets, O rifle.		
		Mean velocity.	Extreme variation.	Mean variation.	Mean velocity.	Extreme variation.	Mean variation.
1893.		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
November 2	50	1,830	179	26.86	1,847	133	23.88
November 3	50	1,820	215	36.64	1,850	166	27.62
November 14	50	1,830	168	23.30	1,857	174	25.34
November 15	50	1,809	250	32.18	1,811	180	32.06
November 16	50	1,799	184	29.62	1,826	154	24.32
November 23	50	1,814	179	30.60	1,866	136	24.30
December 9	50	1,804	233	29.32	1,833	114	22.34
December 26	50	1,819	168	31.62	1,843	136	23.28
Total	400	14,525	1,576	240.14	14,733	1,193	203.14
Mean		1,815.62	197	30.017	1,841.62	149.12	25.39

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ACCURACY AT 500 YARDS.

Date.	Number of targets.	German-silver jacketed bullets, N rifle.		Cupro-nickeled steel jacketed bullets, O rifle.	
		Mean radius circle of shots.	Mean vertical deviation.	Mean radius circle of shots.	Mean vertical deviation.
1893.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
November 2	5	0.742	0.668	0.546	0.406
November 9	5	.718	.546	.780	.666
November 14	5	.674	.546	.580	.404
November 15	5	.580	.466	.520	.372
November 21	5	.716	.593	.428	.287
November 21	5	.688	.608	.532	.420
November 23	5	.652	.576	.492	.328
December 23	5	.628	.517	.574	.378
Total (8 series)	40	5.398	4.520	4.452	3.261
Mean		.6747	.565	.5565	.4076

[Charge, 37 grains old Wetteren powder, sieved and loaded at shops. Primer, E 0.25.]

ACCURACY AT 500 YARDS.

Date.	Number of targets.	German-silver jacketed bullets, N rifle.		Cupro-nickeled steel jacketed bullets, O rifle.	
		Mean radius circle of shots.	Mean vertical deviation.	Mean radius circle of shots.	Mean vertical deviation.
1893.		*Feet.*	*Feet.*	*Feet.*	*Feet.*
November 24	5	1.278	0.925	1.652	1.385
December 28	3	.87	.675	1.39	.9716
Mean	8	1.125	.83125	1.555	1.230

VELOCITY AT 53 FEET.

Date.	Number of shots.	German-silver jacketed bullets, N rifle.			Cupro-nickeled steel jacketed bullets, N rifle.		
		Mean velocity.	Extreme variation.	Mean variation.	Mean velocity.	Extreme variation.	Mean vertical deviation.
1893.		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
November 24	50	2,016	70	14.42	2,023	83	15.24
December 28	20	2,002	74	19.90	2,024	120	19.50
Mean	70	2,012	71.14	15.985	2,023	93.57	16.457

[November 17.—Charge, 33 grains Leonard N fine. Primer, 0.4 grain pellet.]

	Number of shots.	Mean velocity.	Extreme variation.	Mean variation.
		Ft. secs.	*Ft. secs.*	*Ft. secs.*
German-silver jacketed bullets, N rifle	10	1,943.5	37	5.60
Cupro-nickeled steel jacketed bullets, O rifle	10	1,945	33	7

[November 4.—Charge, 36 grains new Wetteren powder, loaded at proof house. Primer, 0.25 grain pellet.]

	Number of shots.	Mean velocity.	Extreme variation.	Mean variation.
		Ft. secs.	*Ft. secs.*	*Ft. secs.*
German-silver jacketed bullets, N rifle	10	1,844	93	27
Cupro-nickeled steel jacketed bullets, O rifle	10	1,885	71.6	17.6

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[November 4.—Charge, 36 grains new Wetteren powder, loaded at proof house. Primer, 0.5 grain pellet.]

	Number of shots.	Mean velocity.	Extreme variation.	Mean variation.
		Ft. secs.	*Ft. secs.*	*Ft. secs.*
German-silver jacketed bullets, N rifle	10	1,949	63	12.6
Cupro-nickeled steel jacketed bullets, O rifle	10	1,948	74	17.7

GENERAL SUMMARY.

German-silver jacketed bullets, N rifle.

Charge.	Mean velocity at 53 feet.	Extreme variation.	Mean variation.	Mean radius.	Mean vertical deviation.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
36 grains new Wetteren, 0.25 primer	1,815.62 1,844	197 93	30.017 27	0.6747 (*)	0.565
36 grains new Wetteren, 0.5 primer	1,949	63	12.6	(*)	
37 grains Wetteren, old, 0.25 primer	2,012	71.14	15.985	1.125	.83125
33 grains Leonard N fine, 0.4 primer	1,943.5	37	5.60	(*)	

Cupro-nickeled steel jacketed bullets, O rifle.

36 grains Wetteren, new, 0.25 primer	1,841.62 1,885	149.12 71.6	25.39 17.6	.5565 (*)	.4076
36 grains Wetteren, new, 0.5 primer	1,948	74.	17.7	(*)	
37 grains Wetteren, old, 0.25 primer	2,023	93.57	16.457	1.555	1.230
33 grains Leonard N fine, 0.4 primer	1,945	33	7	(*)	

* Ten rounds.

CONCLUSIONS.

The accuracy record with the heavy barrel shows the ammunition (36 grains new Wetteren powder) to be inferior to that employed in the lubrication experiments (37 grains old Wetteren powder), in which the record of 35 targets was as follows:

	Radius circle of shots.	Mean vertical deviation.
	Foot.	*Foot.*
Lubricated ammunition	0.358	0.260
Nonlubricated ammunition	.381	.270

The "nonlubricated ammunition" corresponded, in respect to the bullet, with the German-silver jacketed bullets of these later experiments. The inferiority of the new Wetteren powder as to accuracy corresponds with irregular results obtained with the same powder in other tests as to velocity.

As regards the N and O rifles, the results as to accuracy are very favorable as compared with the previous experiments, in which the record of 50 targets was as follows:

	Radius circle of shots.	Mean vertical deviation.
	Feet.	*Feet.*
Lubricated ammunition	1.18	1.04
Nonlubricated ammunition	1.06	.84

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This increase in accuracy in using these rifles with ammunition judged inferior by the standard of the heavy barrel is accounted for by the considerably lower velocity and consequent diminished vibrations of the barrel. In the former case the following velocities were obtained for 500 shots:

	Mean velocity.	Mean variation.
	Ft. secs.	*Ft. secs.*
Lubricated ammunition	1,990	20
Nonlubricated ammunition	1,997	16.8

In the latter case, the following is a summary of the velocity record for 400 shots:

	Mean velocity.	Mean variation.
	Ft. secs.	*Ft. secs.*
German-silver jacketed bullets, N rifle	1,815.62	30.01
Cupro-nickeled steel jacketed bullets, O rifle	1,841.62	25.39

This unexpected reduction in velocity was doubtless due to the primer used, this conclusion being supported by the velocities obtained in the firing of November 4, the primer with 0.5 grain pellet giving increase of velocities of 105 foot-seconds, and 63 foot-seconds over the 0.25 grain primer, the powder charges being in weight the same. It will be noticed that with the 0.5 grain primer velocities were obtained with the 36 grains of new Wetteren powder very nearly approaching the standard velocity, 1,949 foot-seconds and 1,948 foot-seconds in the two rifles N and O, respectively.

The 0.25 grain primer gave rise to continued missfires and hang fires, not being sufficiently strong to produce thorough or satisfactory ignition. It is not deemed possible to associate long hang fires with low velocities and low shots on the targets, as other varying circumstances entered to prevent the connection of effect with cause; low shots on the targets and low velocities occurred often with what appeared to be good ignitions.

Regarding the wear and tear on the rifles N and O, the velocities with the former commenced with a mean of 1,830 foot-seconds and ended with a mean of 1,819 foot-seconds; with the O rifle the velocities commenced with a mean of 1,847 foot-seconds and ended with a mean of 1,843 foot-seconds. It can hardly be stated, either from these or from the accuracy record, that the rifles showed appreciable deterioration during the firing.

In using the old Wetteren powder, the following is a comparison with the previous record:

	Mean velocity.	Extreme variation.	Mean variation.
	Ft. secs.	*Ft. secs.*	*Ft. secs.*
70 shots, N rifle	2,012	71.14	15.985
70 shots, O rifle	2,023	93.57	16.457
Previous record:			
500 shots, N rifle	1,990	.....	20.
500 shots, O rifle	1,997	.....	16.8

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	Mean radius circle of shots.	Mean vertical deviation.
	Feet.	*Feet.*
8 targets, N rifle	1.125	0.83125
8 targets, O rifle	1.555	1.230
Previous record:		
50 targets, N rifle	1.18	1.04
50 targets, O rifle	1.06	0.84

The present record gives higher velocities in both cases, and superior accuracy with the N rifle.

The bores of both rifles were gauged before and after the firing recorded, but the differences of measurements are slight and show no considerable wear.

Very respectfully,

CHARLES H. CLARK,
Captain of Ordnance.

COMMANDING OFFICER FRANKFORD ARSENAL.

[Second indorsement.]

FRANKFORD ARSENAL, PA., *March 30, 1894.*

Respectfully returned to the Chief of Ordnance, U. S. Army.

The results of the final tests are given in the within report.

J. P. FARLEY,
Lieut. Col. of Ordnance, Commanding.

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APPENDIX 5.

REPORTS UPON TESTS OF CUPRO-NICKELED STEEL VERSUS GERMAN-SILVER AS MATERIAL FOR .30-CALIBER BULLET COVERING.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 25, 1893.

SIR: I have the honor to submit, in accordance with your instructions, the following progress report on cupro-nickeled steel jackets for .30-caliber bullets submitted by Hermann Boker & Co., New York. The material used for these jackets is stated to be "steel sheets plated on both sides 5 per cent with 20 per cent nickel-copper." It is understood that a sheet of steel is placed between two sheets of cupro-nickel and the three sheets compacted into one by rolling. The details of the operation are not known. The thickness of jacket is about the same as that of the German-silver jacket used here, except at the point, where the metal is considerably thicker. The advantages claimed by Boker & Co. for their jacket material over the German silver used here are the following:

First. Less difficulty and waste in manufacture.
Second. Less liability to strip when fired.
Third. Does not dirty the barrel of the gun as does the German silver.
Fourth. Much greater penetration.
Fifth. Costs less than German silver.
Sixth. Has 10 per cent less specific weight.

The first experiments have been confined to penetration and deformation.

Penetration of small-arm projectiles has usually been tested in the Ordnance Department by firing against targets composed of inch pine boards an inch apart, at a distance of 500 yards. Against such a target even lead bullets are not greatly deformed.

A more thorough test was thought to be afforded by taking a solid piece of hard oak and firing at it both with and against the grain. It may be mentioned that most of the foreign tests with oak were made by firing in the direction of the grain, which accounts for the great penetrations noted.

The piece of oak first used had not been well seasoned, the interior being quite moist. Another piece, very dry and well seasoned, was afterwards procured from the carpenter's shop. With this the penetration was noticeably less.

The firing was done at a very short distance, to insure a straight path for the bullet, as it was desired to cut open the piece of wood fired at and expose the path of the bullet.

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No. of shot.	Distance fired at.	Caliber of rifle.	Powder charge. Kind.	Powder charge. Grains.	Bullet.	Target—kind of wood.	Penetration.	Remarks.
	Feet.	*Inch.*			*Grains.*		*Inch.*	
1	50	.45	Black	69	500 lead	Oak, not well seasoned.	3.2	Bullet badly deformed. Fired against the grain.
2	50	.30	Wetteren	37	220 German-silver jacket.	do	5.3	Do.
3	3	.30	do	37	do	do	5.3	Do.
4	3	.30	do	37	do	do	5.3	Do.
5	3	.45	Black	69	500 lead	do	3.3	Do.
6	3	.30	Wetteren	37	220 cupro-nickeled steel jacket.	do	19.5	Bullet not deformed. Fired against the grain.
7	3	.30	do	37	do	do	18.5	Bullet not deformed. Bullet penetrated knot in wood. Fired against the grain.
8	3	.30	do	37	230 copper jacket	do	4.	Bullet badly deformed. Fired against the grain.
9	3	.30	do	37	220 German-silver jacket.	do	5.	Do.
10	3	.30	do	37	do	Dry oak, well seasoned.	4.5	Do.
11	3	.30	do	37	220 cupro-nickeled steel jacket.	do	16.5	Bullet not deformed. Fired against the grain.
12	3	.30	do	37	230 copper jacket.	do	6.7	Bullet badly deformed. Fired with the grain.
13	3	.30	do	37	220 German-silver jacket.	do	7.0	Do.
14	3	.30	do	37	220 cupro-nickeled steel jacket.	do	24.2	Bullet not deformed. Fired with the grain.

A photograph, taken by First Lieut. W. C. Wren, Seventeenth Infantry, showing the comparative penetrations of lead, German-silver jacketed, and cupro-nickeled steel-jacketed bullets, in unseasoned oak, fired against the grain (shots 4, 5, and 6), is herewith submitted. (See plate 1, appendix 15, Report of Chief of Ordnance U. S. Army, 1893.)

To test the effect of firing into sand, the following results were obtained with small-caliber bullets fired into a sand butt at a distance of 3 feet:

[Charge: 37 grains Wetteren powder.]

Kind of jacket.	Penetration.	Remarks.
	Inches.	
1 copper	8	Badly deformed.
2 German-silver	8	Do.
3 cupro-nickeled steel	14	Not deformed.

Bullets 2 and 3, used in this test, are herewith submitted.

Attention is invited to the great superiority in penetration and resistance to deformation shown by the cupro-nickeled steel jacket.

It is suggested that a complete series of penetration experiments with the German-silver and cupro-nickeled steel-jacketed bullets be made, noting the comparative effects on different varieties of earth, wood, and metal, bones, etc., and on hasty covers, rifle pits, etc.

In experiments made here, in conjunction with Assistant Surg. La Garde, on cadavers, it was noted that the German-silver jacketed bullet sometimes broke up or stripped on striking hard bones, etc.

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With the cupro-nickeled steel jacket it is probable that this would not have taken place.

Respectfully, etc.,

J. W. BENÉT,
First Lieutenant, Ordnance Department U. S. Army,
In charge of Ballistic Division.

COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., May 6, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army.

The within report will justify extended experiments with the cupro-nickeled steel-jacketed bullet, in line with instructions of the Chief of Ordnance of June 17, 1892, Bureau No. 1217 C.

The German-silver jackets used here have given good results so far as relates to stripping in the gun is concerned, except in certain instances where either improper alloy was used in the German silver or the metal was not properly annealed.

Thirty thousand German-silver jackets, caliber .30, have been condemned in the course of inspection and test at this arsenal for defects due to above-mentioned causes.

Experiments made at this arsenal on bones of cadavers, with German-silver-jacketed bullets, occasionally stripped the jacket, and it is thought this would have been of more frequent occurrence had it not been that reduced charges (assimilating long ranges) were almost invariably employed.

The record of experiments so far made by Lieut. Benét shows remarkable penetration for the cupro-nickled steel-jacketed bullet.

Penetration in well-packed clay with sods at 100 yards gives a penetration of 2 to 1 for the cupro-nickeled steel jacket over either the German-silver (stripped) jacket and the .45 caliber (deformed) lead bullet—both of the latter changing shape materially on impact.

* * * * * * *

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 2, 1893.

SIR: The following is respectfully submitted as the results of comparative tests of bullet jackets so far made, in compliance with your instructions. The German-silver-jacketed bullets were from lots which have lately given, with ordinary velocities, comparatively uniform and favorable results. The cupro-nickeled steel jackets were the first finished from the lot of 15,000 purchased in July from Hermann Boker & Co.

The ammunition used on October 30 was loaded by hand at the proof house with primers having a percussion pellet weighing 0.5 grain. The ammunition used subsequently was hand loaded at the shops, using primers with pellets of 0.25 grain. The conditions of loading in both cases were made perfectly uniform throughout. The charge was 36 grains of new Wetteren powder; the average weight of 50 bullets with German-silver jackets was 220.22 grains, and of 50 with cupro-nickeled steel jackets, 219.66 grains. The heavy accuracy barrel was used

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throughout, and in obtaining targets with the 2 bullets, rounds of 10 were alternated in order to get so far as possible a comparison under uniform conditions of temperature, moisture, wind, etc. The bore was uniformly cleaned after each series of 10 shots in firing for accuracy, and at uniform intervals in firing for velocities.

* * * * * * *

Summary.

VELOCITY AT 53 FEET 11½ INCHES FROM MUZZLE.

Bullet.	Primer.	Number of shots.	Mean velocity.	Greatest velocity.	Least velocity.	Extreme variation.	Mean variation.
	Grain.		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
German-silver jacket	0.5	10	1,953.2	2,002.2	1,925	77	18.6
Do	.25	10	1,882	1,923	1,823	100	25.2
Do	.25	50	1,888	1,956	1,758	198	33.56
Mean	.25	60	1,887				32.136
Cupro-nickeled steel jacket	.5	10	1,969.5	2,012	1,936	76	21.95
Do	.25	10	1,913	1,950	1,882	68	13.2
Do	.25	50	1,900.5	1,960	1,786	174	21.90
Mean	.25	60	1,902.6				20.42

ACCURACY AT 500 YARDS.

Bullet.	Primer pellet.	Number of targets.	Radius circle of shots.	Mean vertical deviation.
	Grain.		*Feet.*	*Feet.*
German-silver jacket	0.5	15	0.3553	0.257
Do	.25	10	.531	.4110
Do	.25	5	.540	.4470
Do	.25	20	.562	.4842
Mean		35	.5503	.4580
Cupro-nickeled steel jacket	.5	15	.2°3	.2°83
Do	.25	10	.387	.2°40
Do	.25	5	.402	.3260
Do	.25	20	.494	.4007
Mean		35	.4503	.3537

Supplementary.

[November 28. Ammunition, 37 grains old Wetteren powder, sieved and loaded at the proof house. Primer, 0.25 grain pellet.]

ACCURACY AT 500 YARDS.

Number of target.	German-silver-jacketed bullets.		Cupro-nickeled steel-jacketed bullets.	
	Radius circle of shots.	Mean vertical deviation.	Radius circle of shots.	Mean vertical deviation.
	Feet.	*Feet.*	*Feet.*	*Feet.*
1	0.53	0.400	0.42	0.295
2	.40	.310	.27	.150
3	.38	.305	.33	.310
4	.49	.260	.32	.205
5	.50	.420	.41	.315
Mean	.46	.339	.35	.255

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VELOCITY AT 59 FEET 11¼ INCHES FROM MUZZLE.

[Fifty shots.]

	German-silver-jacketed bullets.	Cupro-nickeled steel-jacketed bullets.
	Ft. secs.	*Ft. secs.*
Mean velocity	2028	2047
Greatest velocity	2087	2087
Least velocity	1994	1998
Extreme variation	93	89
Mean variation	16.40	15.60

OBSERVATIONS.

Primer.—The 0.5 primer produced ignition uniformly well. With the 0.25 primer ignition was produced with difficulty, there being frequent hang-fires and occasional missfires. It is not deemed possible from these experiments to state definitely what effect, if any, the hang-fires have on the results obtained.

Velocity.—It will be noted that the first firing for velocity, with the 0.5 primer, gave velocities with both bullets considerably higher (66.2′ and 66.9′) than those obtained after with the lighter primer. When the latter ammunition was prepared in accordance with your directions, it was not anticipated that there would be any reduction in this respect.

Other experiments, with ammunition carefully loaded at the proof house, sustain the inference that these differences in velocities were due in great part to differences of primer and not to differences of loading, and emphasize the fact of primer influence in results obtained with smokeless powders.

The velocity with the cupro-nickeled steel jacket was uniformly superior, and the mean variations were much in favor of this jacket.

Accuracy.—In the 15 targets first fired slightly superior mean accuracy was obtained with the German-silver jackets. In the 35 fired subsequently, the accuracy in 28 targets was in favor of the cupro-nickeled steel jackets. The mean accuracy was also decidedly in favor of the latter.

The targets were well grouped as a rule. In some cases, however, one or two shots were at some distance from the cluster, usually low, sometimes high. This seemed to occur more frequently with the German-silver jackets than with those of cupro-nickeled steel.

The results as to accuracy are not quite so favorable as those obtained last June and July, in firing the heavy accuracy barrel with the old Wetteren powder sieved.

This may be attributed in great part to the irregularity of action of the new Wetteren powder, as attested by other late independent experiments. Differences in atmospheric conditions may also account in some slight degree for the differences in results obtained.

The tests of November 28 were made to connect with those of the earlier date referred to above, the ammunition, so far as concerns the German-silver jacketed bullet, being a reproduction of the nonlubricated ammunition then used.

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For convenience of comparison the following summary is given of results obtained with the heavy accuracy barrel in June and July:

Mean of 35 targets.	Radius circle of shots.	Mean vertical deviation.
Lubricated ammunition	.358	.26
Nonlubricated ammunition	.381	.27

In the results of the firing of November 28 a little falling off in accuracy will be noticed with the German-silver jacketed bullets in comparison with the "nonlubricated ammunition" as judged by the above record; also that the accuracy with the nickel-steel jacketed bullet is the best of all.

Very respectfully,

CHARLES H. CLARK,
Captain of Ordnance.

COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 4, 1893.

Approved and respectfully forwarded to the Chief of Ordnance, U. S. Army.

This is the first of a series of experiments inaugurated for the purpose of determining the comparative advantages of various bullet jackets.

The tests outlined in my indorsement of September 13, 1893, will speedily follow.

Progress has been made in the manufacture of cupro-nickeled steel jackets at this arsenal, and it is thought that no more jackets need be purchased, provided a supply of the rolled metal can be obtained similar to that heretofore furnished.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

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APPENDIX 6.

REPORT OF EXPERIMENTS WITH .30-CALIBER SERVICE AND TUBULAR BULLETS.

(5 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., March 30, 1894.

SIR: I have the honor to report, in compliance with your letter of instructions of November 6, 1893, in regard to the Krnka-Hebler tubular bullets, and especially to the statement (p. 1278, U. S. Military Service Institution Journal, November, 1893) "in regard to the reduced resistances offered by bullets having the best possible form of ogival head and ogival base, aside from the tubular form." It was further desired that I should "carefully investigate this subject and make such experiments as could be made without interfering with the regular work at the arsenal to determine what benefit may be derived from changing the present shape of our solid rifle ball, and also to make experiments with the tubular bullets in our .30-caliber rifle."

From the Allgemeine Schweitzerische Militärzeitung, Basel, December 30, 1893, the following description of "The steel tubular bullet, the future projectile," has been obtained:

Firing experiments with the jacketed tubular bullet have shown that the use of the latter is impracticable, because, on account of its unavoidably delicate construction, it becomes very much deformed on leaving the bore.

There remains, therefore, to be considered only the steel tubular bullet, which is the future projectile.

There can evidently be no question as to the deformation of this bullet in the bore from the pressure of the powder gases on its base. This has also been proved by experiment. There is less liability of being deformed during penetration of bodies.

In the course of experiments with the steel tubular bullet to be made in the near future by different countries particular attention (as I here take the liberty of stating) will be paid to the following points:

As the steel tubular bullet is much lighter than that now in use, it will be impossible to attain the required initial velocity with the present rifle using the service charge and with powder of the ordinary granulation. This I have shown in my last article, Das Hohlgeschoss aus Stahl (steel tubular bullet).

The velocity is, and must be, much lower, because for the light projectile the size of granulation hitherto used is much too large, and, consequently only a portion can be burned before the projectile leaves the muzzle. As complete combustion is requisite before the projectile leaves the rifle, when the steel tubular bullet is used, a correspondingly finer (i. e., smaller grain or smaller and somewhat thinner flakes) powder is necessary. Only by this means can the required initial velocity be closely approximated.

It can only be completely obtained by the use of a special powder for the determination of the initial velocity, viz, the cubical smokeless powder made at the Köln-Rottweil works. This is the best smokeless powder in existence for guns of all calibers, as well as for all ranges of small arms of any construction.

Therefore, only by means of the Köln-Rottweil cubical smokeless powders can the theoretical initial velocity, as well as the terminal energy, be fully attained.

In the small-arms cartridges in use by most countries (especially those using grained smokeless powders) the case is generally not completely, but only partially, filled with the powder. This is necessary to prevent too high pressures.

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In using the steel tubular bullet the conditions are changed, and the case can always be completely filled; the gas pressure will not thereby be increased beyond limits, and even in most cases will not reach the average, but remain noticeably lower.

One advantage gained by completely filling the case is that a somewhat larger granulation of powder may be used, not, however, quite as large as that used in the service rifle.

Under some circumstances even the present size of grain may be retained, and notwithstanding this a complete combustion will take place, especially when, by completely filling the cartridge case, the charge is greatly increased from that hitherto used.

The most favorable size of granulation of powder (i. e., the proper size and thickness of the flakes) can only be properly and systematically determined (whether it is intended to fully or only partially fill the cartridge case) by experimental firing.

Such experiments have already been commenced by the well known Roth's Cartridge Works in Vienna (whence the steel tubular bullets and sabots (Führungsspiegel) for experimental firing may be obtained), and already in several countries the subject is being investigated.

Also the most prominent rifle and powder manufactories, as Lowe, in Berlin; Mauser, in Oberndorf, and the Consolidated Köln-Rottweil Powder Works, will, without doubt, soon be in condition to carry on such experiments in order to become thoroughly acquainted with this important subject and ascertain what are the most favorable conditions; for it is evident that it will not be long before the steel tubular bullet will commence, in all countries, to displace the present projectile and finally supersede it.

The transition to the steel tubular bullet for the present arms of small caliber may be predicted to take place in a comparatively very short time, and consequently the present small caliber military rifle will very soon attain its highest possible efficiency.

GENERAL OBSERVATIONS.

Before proceeding to construct Table II, I received the following from Capt. James M. Ingalls, First U. S. Artillery:

My method of computation is as follows: We have the general equation.

$$(1) \qquad \frac{y}{x} = \tan\varphi - \frac{C}{2\cos^2\varphi}\left\{\frac{A(u)-A(V)}{S(u)-S(V)} - I(V)\right\}$$

If we suppose the projectile to be fired horizontally $\varphi = 0$, and the equation becomes (considering y position for convenience)

$$\frac{y}{x} = \frac{C}{2}\left\{\frac{A(u)-A(V)}{S(u)-S(V)} - I(V)\right\}$$

We also have:

$$x = C\Big(S(u) - S(V)\Big)$$

whence by eliminating C, we have:

$$2y\Big(S(u)-S(V)\Big) = \left\{\frac{A(u)-A(V)}{S(u)-S(V)} - I(V)\right\}x^2$$

Substituting known numbers, this becomes

$$26^*\Big(S(u)-2109.0\Big) = \left\{\frac{A(u)-23.33}{S(u)-2109.} - .02421\right\}(1485)^2$$

from which to find u by trial.

It is found that $u = 1114.5$ satisfies the equation; and this substituted in the equation

$$C = \frac{x}{S(u)-S(V)}$$

gives $\log C = 9.52161 = \log w - 2\log d - \log c$

$\therefore \log c = \log w + 0.47839 - 2\log d$

$= \log 22 + 0.47839 - \log 700 - 2\log .308$

$= 9.99861 - 10$

$\therefore c = 0.9968$ for value of $y = 13$

($c = 1.099$ for value of $y = 14.03$. See Table II).

* * * * * * *

*Later and more extended experiment gives $y = 14+$ instead of 13. The point of reference on the target having been more exactly determined. See Table I.

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From the data furnished Capt. Ingalls in December, 1893, the forego-
ng results were determined. Since that date and by applying Ingalls's
entative method Table II* has been derived, in which the values
f "C" "*ballistic coefficient*" and "*c*" "*coefficient of reduction*" have
een determined. The tentative process is most laborious, requiring a
umber of trials to find the *u* functions. This labor may be reduced
fter some practice, or by the use of equation (2) given in Table II; the
triking velocity may be found within 50 ± foot seconds before going
n with the tentative process for its more exact values to satisfy equa-
ion (1).

The data upon which the computations are based is much more
neager than customary, owing to the great expense of making the bul-
ets by hand at a cost in some instances of $2 each.

The horizontal column in the Table II, denominated "Radius of
ircle of shots," with the one just above it, may be taken as an evi-
ence of the dependence to be placed on the values derived by compu-
ation. The upper figures show the number of shots fired upon which
he mean radius is based, and whenever such shots cluster well, as they
o in most instances, the center of impact may be regarded as a true
ndex of the drop of the bullet.

From the value of "C," determined as before stated, Table IV is
onstructed, and it is apparent that the results are unreliable in the
ecords, page 1274, "Journal of the Military Service Institution,"
November, 1893. Such results call for a value of "*c*" to satisfy Table
II, of 0.1050 and "C" 2.7025—far removed from values determined
y experiment and computation at this arsenal, which average 0.67146
or "*c*" for the best form of tubular bullet tested, and for "C" .27363.
Figure 5, Plate I, and Table II.

The computations have been made by Mr. J. J. O'Reilly, employing
ngalls's formulas and tables.†

The results obtained are arranged in tabular form for ease of inspec-
ion and comparison by means of reference to numbered columns com-
non to Tables I, II, and IV, in connection with the following mem-
randa:

In Table II, the muzzle velocities are derived from the sectional
ensity as a *ballistic coefficient* "C," the *coefficient of reduction* "*c*,"
eing taken as unity, in advance of its computation, and hence are a
ew feet less than would result from taking the true *ballistic coefficients*
ater determined, and which are given in the fourth horizontal column
elow the sectional density in Table II as a denominator. The equa-
ion for values given in column 1 of the same table shows,

For example: $S(2027.9) - \frac{53.}{.3313} = S(2074.5)$ { "C" taken as sectional density.

and $S(2027.9) - \frac{53.}{.30127} = S(2079.2)$ { "C" taken as true *ballistic coefficient.*

This latter value for muzzle velocity if used would involve a repeti-
ion of the work and unnecessary labor of computation, carrying with
t further changes in "C," and so on.

The value of "C" given in Table IV has been used in computing
he remaining velocities for the various ranges indicated, using the
nuzzle velocity originally determined as stated.

* The best results in this table are embraced in Table V of supplemental report, page 95, for comparison with later ones.

† The construction of the various tables by Mr. J. J. O'Reilly involved great labor and skill.

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The results given in column 3, Table II, differ from those in column 4 in this, that whilst the lesser weight of the bullet due to a tubular channel enters the computations in both cases, yet the area of cross section was treated erroneously in the one case (column 3) as an area of a solid section; in the other the true area of cross section was employed. The difference in the two cases as relates to sectional density is shown as follows, and leads to the rejection of results in column 3:

$$\text{Column 3, sectional density} = \frac{162}{7000} = \frac{162}{.308^2} = .24396$$

$$\text{Column 4, sectional density} = \frac{162}{7000} = \frac{162}{.308^2 - .11^2*} = .27963$$

It is to be observed that the sectional density of any given (homogeneous) cylinder is not changed by the introduction of a cylindrical tubular channel, and that such form of projectile, preserving as it does its ratio of weight to area of cross section, becomes, by the displacement of metal in the manner stated, a practical subcaliber projectile, with all the ballistic advantages and disadvantages that such projectiles are known to possess. That Prof. Hebler may succeed by the use of a proper sabot in imparting a high initial velocity to such projectile without undue pressure in his gun is indisputable, and that after having gained such advantage in this projectile the accuracy is not seriously impaired, is also admitted.

In the taper, front and rear of the bearing point or rotating ring of his most approved form of bullet, Plate III, the advantages gained over the cylindrical form with its tube, in lessening the *coefficient of reduction* "*c*," is somewhat offset by the reduction of weight which enters as a potent factor in the relation $C = \frac{w}{c\,(D^2 - d^2)}$, $(D^2 - d^2)$ remaining constant.

Exhibits of some of the figures in Plate I, and a bullet recovered after penetration test, as illustrated in the photograph Plate IV and V, are submitted herewith.

*Taken as ".12 for 160 and 87.5 grains bullets and ".118 for 104 grains bullets.

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TABLE I.—*Experimental firing with service and tubular bullets, caliber .30.*

Reference to accompanying drawing.	Reference to number of column in Table II.	Description of bullets, etc. [See references to Table II and drawing. All loaded cartridges were of uniform length.]	Heavy accuracy barrel. (Pl. II.) Charge of powder. Kind.	Weight.	Targets at 1,490.766 feet. No.	Shots each.	Radius of circle of shots.	Mean vertical deviation.	Vertical distance of center of impact from axis of bore prolonged.	Pressures per square inch.	Velocities at 53 feet from muzzle. Number of shots.	Mean velocity.	Greatest velocity.	Least velocity.	Extreme variation in velocity.	Mean variation in velocity.
				Grains.			*Feet.*	*Feet.*	*Feet.*	*Pounds.*		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
Figure 1, plate 1.	1	Service bullet, 220 grains, German-silver jacket, loaded as usual with space of 0.1″ + in case.	Old Wetteren.	37	1	10	0.27	0.18	13.886	.....	10	2,027.9	2,060	1,976	84	18.5 a
					1	10	.35	.22	14.136							
					1	10	.44	.32	14.086							
		Mean					.353	.24	14.036							
Do....	2	Service bullet, 220 grains, German-silver jacket.	Black.....	54	1	10	.79	.6	23.35	.....	5	1,472.2	1,491	1,461	30	10.6
Figure 2, plate 1.	3, 4	Tubular bullet, 162 grains, jacketed, rested on asbestos wad ½″ + thick, weight 3.8 grains having a projection fitted to close the channel until free from action of the powder gases.	Old Wetteren.	37	1	10	.81	.395	14.436	.....	10	2,209	2,253	2,182	71	18.4
					1	10	.84	.665	14.186							
					1	10	.85	.530	14.286							
		Mean					.833	.530	14.3							
Figure 3, plate 1.	5	Short, solid bullet, 162 grains, jacketed, supported in case by pasteboard wads extending nearly 0.4″ weighing 5.5 + grains.	Old Wetteren.	37	1	10	2.15	1.43	14.906	.....	10	2,101.3	2,125	2,078	47	13.1
					1	10	1.60	.66	15.366							
					1	10	2.17	1.30	14.773							
		Mean					1.973	1.13	15.015							
Figure 4, plate 1.	6	Tubular bullet, 160 grains, jacketed, channel funnel-shaped.	Old Wetteren.	37.5	1	6	.56	.51	*13.95	.....	5	2,181.6	2,197	2,157	40	11.9

*One shot of the 6 rejected, as it dropped 9 feet below group of the other 5 shots.

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TABLE I.—*Experimental firing with tubular and solid bullets, caliber .30*—Continued.

Reference to accompanying drawing.	Reference to number of column in Table II.	Description of bullets, etc. [See references to Table II and drawing. All loaded cartridges were of uniform length.]	Heavy accuracy barrel. (Pl. II.)							Velocities at 53 feet from muzzle.					
			Charge of powder.		Targets at 1,490.766 feet.		Radius of circle of shots.	Mean vertical deviation.	Vertical distance of center of impact from axis of bore prolonged.	Pressures per square inch.	Number of shots.	Mean velocity.	Greatest velocity.	Least velocity.	Extreme variation in velocity.	Mean variation in velocity.
			Kind.	Weight.	No.	Shots each.										
				Grains.			*Feet.*	*Feet.*	*Feet.*	*Pounds*		*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
Figure 5, plate 1.	7, 8, 9	Tubular bullet, 104 grains, steel, channel cylindrical, with funnel-shaped opening at rear. Vulcanized fiber sabot.	Leonard, J..	45	1	2	.975	.975	6.97	.....	3	2,893.7	3,128.8	2,719.2	409.6	124.5
				42	1	5	1.78	1.27	7.05	.....	4	3,005.9	3,058.2	2,901	157.2	66.7
				33	1	3	.766	.216	9.3	.....	1	2,588	.....	.....	.....	.....
	10	Long, solid bullet, 131 grains, steel, pointed front without channel, like fig. 5, pl. 1.	Leonard, J..	42	1	2	1.50	1.04	8.65	.....	3	2,892.7	2,973	2,789.8	183.2	68.6
Figure 6, plate 1.	11	Tubular bullet, 87.5 grains, steel, channel funnel-shaped. Vulcanized fiber sabot.	Old Wetteren.	37.5	1	4	*3.96	2.2	18.15	.....	2	.,810	1,820	1,801	19	9
Figure 5, plate 1.	.....	.....do	Old Wetteren.	52	.....	.....	.....	.....	.....	57,000	1	2,743.7	.....	.....	.....	.....
				55	.....	.....	.....	.....	.....	63,000	1	2,971	.....	.....	.....	.....
Do....	.....	.....do	Leonard, J..	42	.....	.....	.....	.....	.....	46,000	1	3,048	.....	.....	.....	.....
				42	.....	.....	.....	.....	.....	45,700	1	3,038	.....	.....	.....	.....

*This inaccuracy disparages comptations for this bullet.

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TABLE 11.—*Ballistic data for service and experimental bullets, caliber .40.*

Ingalls's general formula, for 0° angle of departure, to determine C and e, etc. (I) $2y\,(S(u)-S(V))=\begin{Bmatrix}A(u)-A(V)\\S(u)-S(V)\end{Bmatrix}-I(V)\Big\}x^2$	1	2	3	4	5	6	7	8	9	10	11	12	13
	Service (fig. 1, pl. 1).	Service with 54 grains black powder (fig. 1, pl. 1).	Tubular (fig. 2, pl. 1).		Short, solid (like fig. 2). (Fig. 3, pl. 1.)	Tubular (fig. 4, pl. 1).	Tubular (fig. 5, pl. 1).			Long, solid (like fig. 5), point on end, and without channel.	Tubular (unreliable). (Fig. 6, pl. 1.)	Hebler tubular (p. 1274, J. M. S. I., November, 1893).	Hebler ballistic coefficient reduced by change of decimal.
Weight.....grains	220	220	162	162	162	160	104	104	104	131	87.5	166.7	166.7
Diameter, inch, $=\sqrt{D^2-d^2}$ for columns 4, 6, 7, 8, 9, 11, 12, and 13 $=d_1$	.308	.308	.308	.28769	.308	.28366	.28489	.28489	.28489	.308	.28366	.2887	.2887
Sectional density $=\frac{w}{d^2}$	.3313	.3313	.24396	.27963	.24396	.28406	.18306	.18306	.18306	.19727	.15335	.28567	.28567
Velocity at 53 feet from muzzle...foot seconds	2,027.9	1,472.2	2,209	2,209	2,101.3	2,181.6	2,893.7	3,005.9	2,588	2,892.7	1,810	2,355.4	.....
Velocity at muzzle, V.....foot seconds	2,074.5	1,506	2,279.2	2,269.3	2,167	2,243.3	3,002.8	3,111.6	2,696.6	2,994.1	1,900	2,362	2,362
Velocity at 1,490.766 feet from muzzle, $=u$ foot seconds	1,058.5	950	969.2	971.5	972.5	996	1,472	1,445	1,178	1,140	944	2,184	1,097.5
Ballistic coefficient, $C=\frac{1490.766}{S(u)-S(V)}$	.30127	.36905	.22283	.22487	.23694	.21422	.29492	.27188	.25410	.21613	.25794	2.70425	.270425
Coefficient of reduction, $e=\frac{w}{C\,d^2}$	1.099	.8977	1.095	1.2435	1.030	1.326	.62070	.67328	.72040	.91278	.6022	.1056	1.0564
Time of flight, $T=C(T(u)-T(V))$	1.04	1.302	1.070	1.074	1.090	.940	.72638	.72647	.86293	.84375	1.184	.657	.956
Observed ordinate, $y=h$.....feet	14.03	23.35	14.3	14.3	15.015	13.95	6.97	7.05	9.3	8.65	18.15	*6.67	*11.6
$g''=32.16-g'=\frac{2h}{T^2}$.....feet	26.01	27.56	25.04	24.82	25.14	31.49	20.42	26.72	24.98	24.30	25.89	30.9	25.37
Energy at muzzle, $\frac{1}{2}MV^2$.....foot pounds	2,104	1,109	1,870	1,854	1,690	1,784	2,083	2,230	1,680	2,608	702	2,066	.....
Energy at target, $\frac{1}{2}Mu^2$.....foot pounds	548	441	338	340	340	353	501	482	321	378	173	1,766	.....
Energy at muzzle, per square inch, foot pounds	28,233	14,880	25,037	28,514	22,685	28,232	32,674	35,084	26,350	35,008	11,110	30,855	.....
Energy at target, per square inch, foot pounds	7,350	5,920	4,538	5,226	4,569	5,579	7,852	7,586	5,028	5,075	2,741	26,380	.....
Extreme variation in velocity at 53 feet from muzzle.....foot seconds	84	30	.....	71	47	40	409.6	157.2	1 shot.	183.2	19	.....	.....
Number of shots	30	10	.....	30	30	6	2	5	3	2	4	.....	.....
Radius of circle of shots	.353	.79	.....	.833	1.973	.56	.975	1.78	.766	1.50	3.96	.....	.....

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TABLE II.—*Ballistic data for service and experimental bullets, caliber .30*—Continued.

Ingalls's general formula, for 0° angle of departure, to determine C and c, etc. (I) $2y\,(S(u)-S(V))=\left\{\begin{matrix}A(u)-A(V)\\S(u)-S(V)\end{matrix}\right\}-I(V)\left\{x^2\right.$	1	2	3	4	5	6	7	8	9	10	11	12	13
	Service (fig. 1, pl. 1).	Service with 54 grains black powder (fig. 1, pl. 1).	Tubular (fig. 2, pl. 1).		Short, solid (like fig. 2). (Fig. 3, pl. 1).	Tubular (fig. 4, pl. 1).	Tubular (fig. 5, pl. 1).			Long, solid (like fig. 5), point on end, and without channel.	Tubular (unreliable). (Fig. 6, pl. 1.)	Hebler tubular (p. 1274, J. M. S. I., November, 1893).	Hebler ballistic coefficient reduced by change of decimal.
Time of flight, (2), $T'=\sqrt{\frac{2h}{32.16}}$ †	.93408	1.2050	.94303	.94303	.90632	.93142	.65838	.66214	.76050	.73344	1.0624	.63668	.84935
Mean velocity, $v=\frac{1490.766}{T'}$ †	1,595.6	1,237.1	1,580.8	1,580.8	1,542.7	1,600.5	2,264.3	2,251.4	1,960	2,032.6	1,403.2	2,341.5	1,755
Striking velocity, $u'=2v-V$ †	1,116.7	968.2	882.4	892.3	918.4	960.7	1,525.8	1,496.9	1,223.4	1,172.5	906.4	2.321	1,148
Difference, $u'>u$ (formulas (2) and (1))†	+58.2	+18.2	−86.8	−79.2	−54.1	−35.3	+53.8	+51.9	+45.5	+32.5	−37.6	+137	+50.5

† It may be remarked as a proof of the accuracy of this means of establishing the trajectory, that the curve here plotted by calculation agrees within 6 inches with that obtained at Woolwich by experiment.

This reference being to a trajectory based upon the formula—

$$h=\tfrac{1}{2}g\,t^2$$

and terminal velocity—

$u'=$(2 mean velocity − initial velocity).

The close agreement of these remaining velocities with those determined by Ingalls's formula is very satisfactory in the absence of more exact instrumental determination of remaining velocities at 500 yards. (See later experiments in this connection, pages 93 to 96.)

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TABLE III.—*Ballistic data for Hebler tubular bullet.*

[Derived from results given on page 1274, Journal of the Military Service Institution, November, 1893.]

Weight of bullet.....10.8 grams = .02381 lb. = w
Diameter of bullet..... 8 millimeters = .315 inch = D
Diameter of channel at front. 3.2 millimeters = .126 inch = d
Sectional density = $\frac{w}{D^2 - d^2}$ = .28567

Velocities V and u.	Ranges X	S (u)—S (V) Z	C = $\frac{X}{Z}$
Ft. secs.	*Feet.*		
2,362	0	0	0
2,165	1,641	612.8	*2.6778
1,988	3,282	1,213.1	2.7054
1,824	4,920	1,819.1	2.7046
1,673	6,561	2,427.3	2.7030
1,535	8,202	3,033.2	2.7040

* Rejected.

Mean of last four values C = $\frac{X}{Z}$ = 2.70425

$$c = \frac{w}{C\,(D^2 - d^2)}$$

log .083349 = $D^2 - d^2$ = 8.9209004 — 10
log 2.70425 = C = 0.4320469
9.3529473 — 10
log .02381 = w = 8.3767594 — 10
log .10560 = c = 9.0238121 — 10

Mean C = 2.70425. c = .10560.

Results derived from other data given in the Journal, from the first two ranges in each table, as follows:

	C.	c.
First table (p. 1275)	1.9456	.10606
Second table (p. 1275)	3.3542	.08271
First table (p. 1276)	1.9435	.10303
Second table (p. 1276)	1.6910	.11841
First table (p. 1277)	.28777	1.0211
Second table (p. 1277)	.39545	.83586

TABLE IV.—*Computed ballistic coefficient, and velocities at various ranges, for service and experimental solid and tubular bullets, caliber .30, as compared with results reported for the Hebler bullet.**

	1	2	3	4	5	6
	Velocities.					
	Service (fig. 1, pl. 1).		Tubular (fig. 2, pl. 1).		Short solid (fig. 3, pl. 1).	Tubular (fig. 4, pl. 1).
Ballistic coefficient	.30127	.36905	.22283	.22487	.23694	.21422
	Ft. secs.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
Range, 0 feet	2,074.5	1,506	2,279.2	2,269.3	2,167	2,240.3
Range, 1 641 feet	1,013	925	924	926	929	898
Range, 3,282 feet	713	702	591	595	610	567
Range, 4,920 feet	517	540	383	387	406	361
Range, 6,561 feet	375	416	248	252	270	230
Range, 8,202 feet	272	320	161	164	179	148

*The best results in this table are embraced in Table VI of supplemental report for comparison with later ones.

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TABLE IV.—*Computed ballistic coefficient, and velocities at various ranges, etc.*—Cont'd.

	7	8	9	10	11	12	13
	Velocities.						
	Tubular (fig. 5, pl. 1).			Long solid. Point on end, without channel.	Tubular (fig. 6, pl. 1). (Unreliable.)	Hebler tubular.	
						From page 1274 Journal Military Service Institution, November, 1893.	Ballistic coefficient reduced by change of decimal point.
Ballistic coefficient	.29492	.27188	.25410	.21613	.25794	2.70425	*.270425
	Ft. secs.	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*
Range, 0 feet	3,002.8	3,111.6	2,696.6	2,994.1	1,900	2,362	2,362
Range, 1,641 feet	1,370	1,337	1,096	1,054	907	2,165	1,038
Range, 3,282 feet	822	791	705	644	617	1,988	699
Range, 4,920 feet	591	555	482	413	424	1,824	489
Range, 6,561 feet	427	389	330	264	292	1,673	342
Range, 8,202 feet	307	272	225	159	200	1,535	239

* On this assumption the velocity at 1,490.766 feet from muzzle is 1,097.5 foot seconds. See column 13, Table II.

Very respectfully,

J. P. FARLEY,
Lieutenant Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

ORDNANCE OFFICE, WAR DEPARTMENT,
WASHINGTON, *April 18, 1894.*

SIR: I am instructed by the Chief of Ordnance to acknowledge the receipt of your report, dated March 30, 1894, on results of experiments with .30-caliber tubular bullets. The papers have been referred to the commanding officer, Springfield Armory, for his information.

Your report does not indicate whether these experiments are still to be continued, but it is desired that they will be continued as far as may appear necessary to arrive at more definite conclusions with reference to the ballistic qualities, penetration, etc., of the steel tubular bullets, using the vulcanized fiber sabot. It is observed in this connection that Professor Hebler attaches considerable importance to the use of properly granulated powder with these light bullets. It is probable that the Department may receive before long some samples of the smokeless powder from the Cologne Rottweil Works, Germany, to which Professor Hebler has referred.

Respectfully,

R. BIRNIE,
Captain, Ordnance Department, U. S. Army.

The COMMANDING OFFICER FRANKFORD ARSENAL.

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SUPPLEMENTAL REPORT.

Details of experiments made at Frankford Arsenal in June, 1894, with service and tubular bullets.

[Service bullet.]

Date and number of shots.	Observed velocities. v,	v'.	Computed velocities. V,	u.	Observed ordinate, y.		Observed time of flight T. $x=1,500'$.	Observed radius of circle of shots.
	$x=50'$.	$x=1,450'$.	$x=0'$.	$x=1,500'$.	$x=1,490'.776$.	Corrected for $x=1,500'$.		
1894.								
June 2:	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Feet.*	*Feet.*	*Seconds.*	*Feet.*
1	1,982	1,166						
2	1,986	1,170						
3	1,982	1,180						
Mean	1,983	1,172	2,021	1,152				.136
June 11:								
1	1,984	(*)						
2	1,994	(*)						
3	1,986	(*)			12.45			
4	1,988	(*)			13.83			
5	1,972	(*)			13.63			
6	1,976	(*)			14.15			
7	1,990	(*)			13.85			
8	1,982	(*)			14.07			
9	1,980	(*)			14.15			
10	1,974	(*)			13.63			
Mean	1,983	1,172	2,021	1,152	13.72	13.96		.57
June 16:								
1		(*)					Lost.	
2		(*)					1.00439	
3		(*)					.97048	
4		(*)					.99444	
5		(*)					Lost.	
Mean	1,983	1,172	2,021	1,152			†.98977	1.48

*The same lot of cartridges as 1, 2, and 3 of June 2, 1894.

†If this time of flight, determined instrumentally for the whole range, be utilized in Ingalls's formula $T=C(T(u)-T(V))$, the remaining velocity for the service 220-grain bullet is found to be 1,157 foot seconds, as against 1,152 foot seconds instrumentally determined; and for the Krnka-Hebler bullet 1,778 foot seconds as against 1,649 foot seconds instrumentally determined, the values of C being taken from columns 1 a and 8 a respectively. (Table V).

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Details of experiments made at Frankford Arsenal in June, 1894, etc.—Continued.

[Tubular bullet.]

Date and number of shots.	Observed velocities. v.	v'.	Computed velocities. V,	u.	Observed ordinate. y.		Observed time of flight. T.	Observed radius of circle of shots.
	$x = 50'$.	$x = 1,450'$.	$x = 0'$.	$x = 1,500'$.	$x = 1490'.766$.	Corrected for $x = 1,500'$.		
1894.								
June 9:	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Feet.*	*Feet.*	*Seconds.*	*Feet.*
1	3,034.3	Lost.						
2	3,068.4	Lost.						
3	3,134.3	Lost.						
4	3,053.9	1,685						
5	3,038.4	Lost.						
6	3,017.9	Lost.						
7	2,992.8	Lost.						
Mean	3,054	1,685	3,108	1,649				1.3
June 14:								
1		(*)			4.9			
2		(*)			9.9			
3		(*)			6.7			
4		(*)			9.7			
5		(*)			3.5			
6		(*)			5.5			
Mean	3,054	1,685	3,108	1,649	6.7	6.81		2.38
June 16:								
1		(*)					Lost.	
2		(*)					Lost.	
3		(*)					.60803	
4		(*)					.5500	
5		(*)					Lost.	
Mean	3,054	1,685	3,108	1,649			†.57901	2.88

* The same lot of cartridges as Nos. 1 to 7 of June 9, 1894.

†If this time of flight, determined instrumentally for the whole range, be utilized in Ingalls's formula T=C (T (*u*)—T(V)), the remaining velocity for the service 220-grain bullet is found to be 1,157 foot seconds, as against 1,152 foot seconds instrumentally determined; and for the Krnka-Hebler bullet 1,778 foot seconds as against 1,649 foot seconds instrumentally determined, the values of C being taken from columns 1 a and 8 a respectively. (Table V).

EXPLANATION OF TABLES V AND VI.

Columns 1 and 8 of Tables V and VI are taken respectively from Tables II and IV, report of March 30, 1894, and contain the best results then obtained respectively with the service and tubular bullets.

Columns 1 a and 8 a, Tables V and VI, are based upon observed velocities v and v', obtained in June, 1894.

Columns 1 b and 8 b, Tables V and VI, are based on observed ordinates, y, corrected for range, obtained in June, 1894.

In Table VI we have velocities at various ranges corresponding with the March and June derived values of C for the service and tubular bullets.

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TABLE V.

Notations.	Service bullet. 1. From report of March 30, 1894.	Service bullet. 1 a. From experiments in June, 1894. Observed velocities v and v'.	Service bullet. 1 b. From experiments in June, 1894. Observed ordinate at 1,490.766, corrected for 1,500 range.	Notation.	Tubular bullet. 8. From report of March 30, 1894.	Tubular bullet. 8 a. From experiments in June, 1894. Observed velocities v and v'.	Tubular bullet. 8 b. From experiments in June, 1894. Observed ordinate at 1,490.766, corrected for 1,500 range.
Weight of bullet.....w....grains..	220	220	220	.....	104	104	104
Diameter of bullet, solid...d.....inch..	.308	.308	.308	$\sqrt{D^2 - d^2}$	.28489	.28489	.28489
Sectional density of bullet. $\frac{w}{d^2}$	.3313	.3313	.3313	$\frac{w}{D^2 - d^2}$	.18306	.18306	.18306
Velocity at—							
0.....range V..foot secs..	2,074.5	2,021	2,021	.....	3,111.6	3,108	3,108
50.....range v .....do....	.....	1,983	.....	.....	.....	3,054	.....
53.....range v .....do....	2,027.9	.....	1,983	.....	3,005.9	.....	3,054
1,450.....range v'.....do....	.....	1,172	.....	.....	.....	1,685	.....
1,490.766.....range u .....do....	1,058.5	.....	.....	.....	1,445	.....	.....
1,500.....range u .....do....	.....	1,152	1,107	.....	.....	1,649	1,535
Ballistic coefficient.....C	.30127	.37400	.34687	.....	.27188	.32988	.29693
Coefficient of reduction...c	1.099	.88583	.95512	.....	.67328	.55491	.61649
Ordinate—							
observed .....y .....feet..	*14.03	.....	*13.72	.....	*7.05	.....	*6.7
corrected.....y .....do....	.....	.....	13.96	.....	.....	.....	6.81
computed .....y .....do....	.....	13.472	.....	.....	.....	6.54	.....
Time of flight .....T ...seconds..	1.04	.....	.....	.....	.72647	.....	.....
$g'' = 32.16 - g' = \frac{2y}{T^2}$ ..... g'' .....feet..	26.01	26.944	26.63	.....	26.72	28.16	27.20
Energy at muzzle.....E.foot pounds.	2.104	1,996	1,996	.....	2,236	2,231	2,231
Energy at target.....e .....do....	548	650	600	.....	482	603	544
Energy per square inch:							
At muzzle .....E .....do....	28,233	26,787	26,787	.....	35,084	35,003	35,003
At target .....e .....do....	7,350	8,704	8,034	.....	7,566	9,853	8,538
Extreme variation in velocity.foot secs..	34	$v = 41$	22	.....	157.2	1 shot.	1 shot.
Number of shots for accuracy.....	30	$\frac{v}{3} = 14$	8	.....	5	1	6
Radius of circle of shots .....feet..	.358	.136	.57	.....	1.78	1.3	2.38
Time of flight $T' = \sqrt{\frac{2h.}{32.16}}$. T'.seconds..	.93408	.91532	.93108	.....	.66214	.63774	.65077
Mean velocity $v'' = \frac{X}{T}$ ..... v'' ft. secs..	1,596	1,639	1,611	.....	2,251.4	2,352	2,305
Striking velocity $u' = 2v'' - V$..u'...do....	1,116.7	1,257	1,201	.....	1,496.9	1,596	1,502
Difference.....$u' > u$.....	+58.2	+105	+194	.....	+51.9	−53	−33

*The barrel laid very accurately in June experiments as determined by surveyor's level and other checks. Laid by sighting in March.

TABLE VI.

BALLISTIC COEFFICIENTS AND CORRESPONDING VELOCITIES FOR RANGES SPECIFIED. (C.)

Ranges.	Service bullet. 1. From Table IV, report of Mar. 30, 1894. Observed ordinate, y.	Service bullet. 1 a. From experiments in June, 1894. Observed velocities, v and v'.	Service bullet. 1 b. From experiments in June, 1894. Observed ordinate, y, corrected.	Tubular bullet. 8. From Table IV, report of Mar. 30, 1894. Observed ordinate, y.	Tubular bullet. 8 a. From experiments in June, 1894. Observed velocities, v and v'.	Tubular bullet. 8 b. From experiments in June, 1894. Observed ordinate, y, corrected.
.....	.30127	.37400	.34687	.27188	.32988	.29693

VELOCITIES.

Feet.	Ft. secs.	Ft. secs.	Ft. secs.	Ft. secs.	Ft. secs.	Ft. secs.
	2,074.5	2,021	2,021	3,111.6	3,108	3,108
1,641	1,013	1,101	1,062	1,337	1,556	1,435
3,282	713	799	767	791	904	841
4,920	517	617	581	555	665	606
6,561	375	476	439	389	495	438
8,202	272	368	333	272	364	316

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In concluding experiments with the Krnka-Hebler bullet at this arsenal it will be seen from Table VI that the ballistic coefficient derived from Ingalls's formula, employing the observed ordinate as the basis of computation, is well confirmed by the observed velocity records herein. This remark applies with force to the record of the service 220-grain bullet, the remaining velocity for which was instrumentally determined as a mean of three shots.

The extreme accuracy required to obtain instrumental remaining velocities with the Krnka-Hebler bullet at the 500-yard range led to the loss of six of the expensive hand-made bullets, with but one record in seven shots fired, and this even after many preliminary shots had been expended.

The deductions from this single record, however, are so well sustained by other data and by analogy in the case of the service-bullet velocities observed and computed* as to make it available at least for all practical purposes.

The radius of the circle of shots in the June experiments disparage the record and conclusions in the earlier records and place the tubular bullet in this respect at a marked disadvantage as compared with the service bullet, the comparison in March, 1894, being for mean radius of circle of shots 0.353′ as against 1.31′, and 0.75′ as against 2.10′, in the June experiments, in favor of the service bullet for a range of 500 yards.

It will also be observed that, contrary to claims made for the tubular bullet, it suffers greater retardation from the air than the service bullet, the velocity falling off more rapidly in all of the forms of tubular bullets employed, and that the form of bullet made pursuant to Professor Hebler's suggestions reduces from about 3,000 foot seconds muzzle velocity to the same remaining velocity at 2,700 yards as that of the service bullet having about 2,000 foot seconds muzzle velocity.

The projectile energies of the tubular and service bullets being equal at 450 yards, short of this distance the penetration of the tubular bullet should be the greater, so long as it is not deformed, a difficulty not as yet overcome in the case when well-seasoned oak, across the grain, is employed, the actual penetrations in oak being in the ratio of 7 to 16.5 in favor of the service bullet.

Respectfully submitted.

J. P. FARLEY,
Lieutenant Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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* Table V shows for service bullet at range 500 yards 1,152 foot seconds remaining velocity observed and 1,107 foot seconds computed from ordinate, like comparison in the case of the tubular bullet being 1,649 foot seconds and 1,535 foot seconds.

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Krnka – Hebler Tubi

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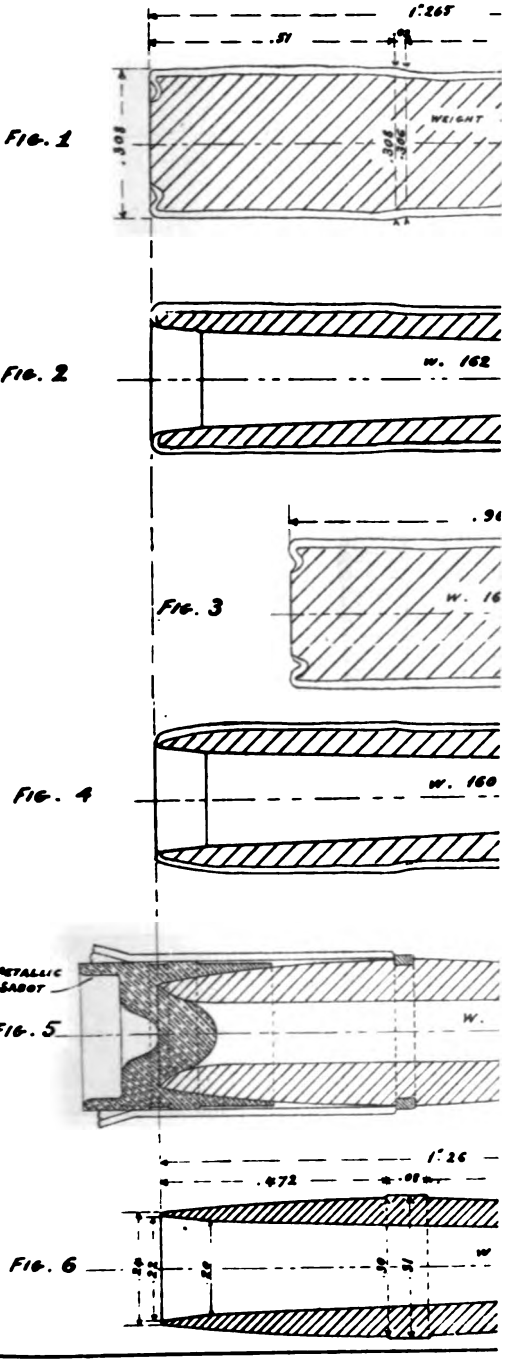

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Krnka-Hebler Tubular Bullet

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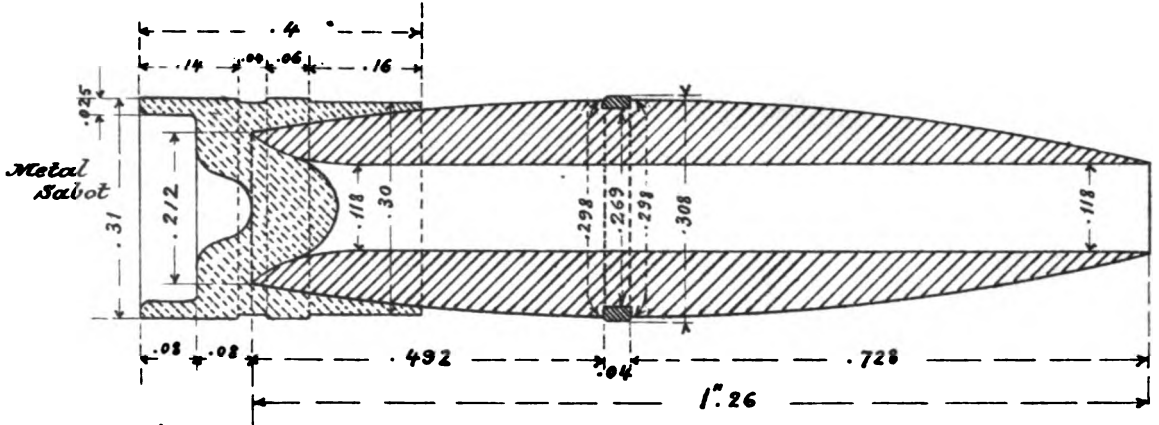

For vulcanized fiber sabot see Plate I. Fig. 9.

Revised March 1894.

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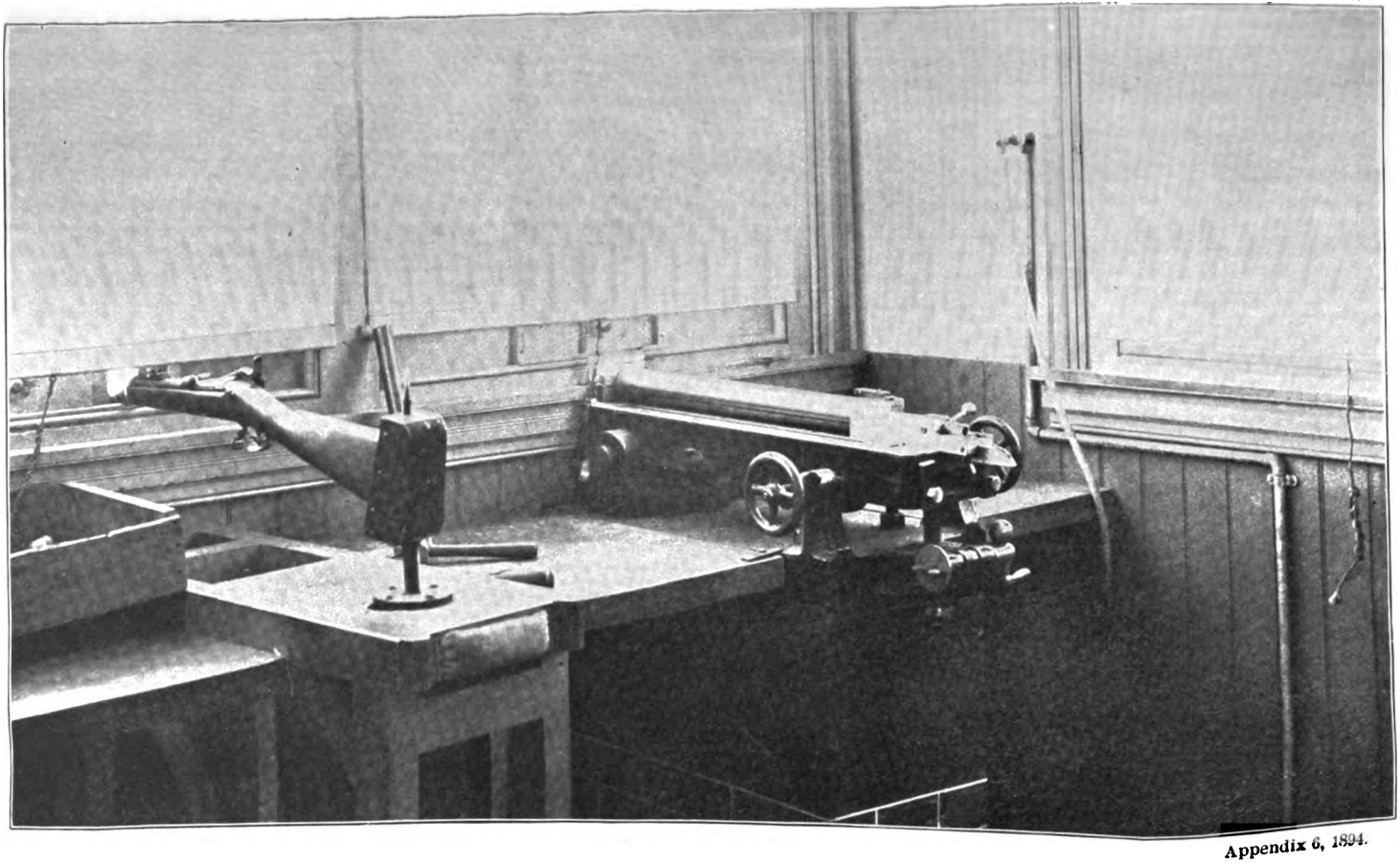

Appendix 6, 1894.

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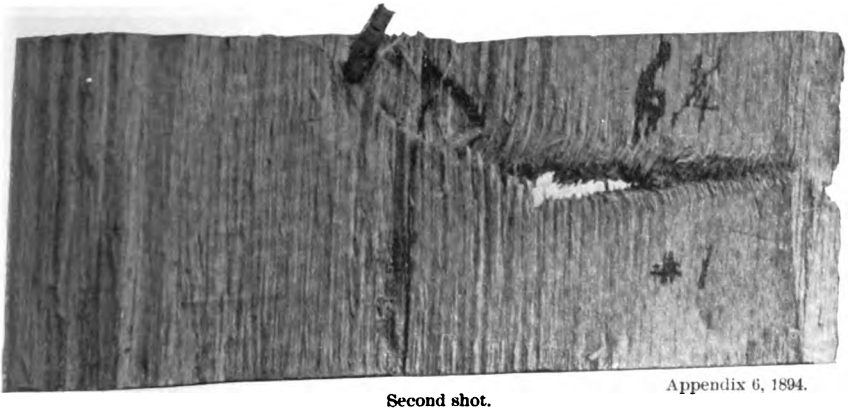
PLATE IV.

First shot.



Second shot.

Appendix 6, 1894.

PENETRATION 104 GRAIN TUBULAR BULLET.

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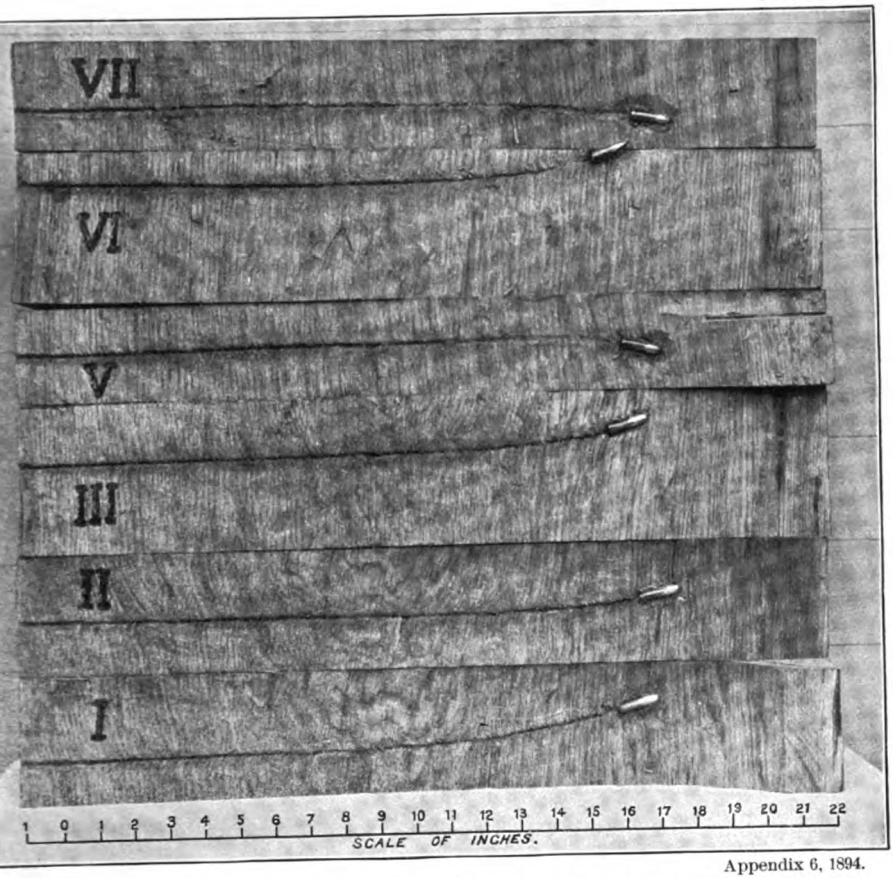
PLATE V.



Appendix 6, 1894.

SERVICE BULLETS—PENETRATION IN OAK AT 3 FEET FROM MUZZLE.

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APPENDIX 7.

TRAJECTORIES OF .30-CALIBER SERVICE BULLET AND HEBLER TUBULAR BULLET.

(1 plate.)

FRANKFORD ARSENAL,
Philadelphia, Pa., September 3, 1894.

SIR: In obedience to your letter of June 23, 1894, I have the honor to submit the following tables, embodying the results of computations to determine the ordinates and abscissas of certain points of the trajectories of the service (.30 caliber) and tubular (.30 caliber) bullets for ranges of 500, 1,000, and 1,500 yards, together with the angles of departure and fall and the final velocity in each case. These results are based upon the values of C determined by you for the service and tubular .30-caliber bullets.

A drawing of the trajectories is submitted herewith.

The data for each bullet called for in Ordnance Office letter of April 16, 1894, is also respectfully submitted.

Very respectfully, your obedient servant,

COLDEN L'H. RUGGLES,
First Lieutenant of Ordnance.

The COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 23, 1894.

SIR: Please compute trajectories, and furnish other data called for in Ordnance Office letter of April 16, 1894, for service, and also tubular bullets, caliber .30, with a drawing of trajectories for 500, 1,000, and 1,500 yards in one group, with common origin for each bullet, with angles of departure and fall, final velocities, maximum ordinates and ordinates at every 100 feet for the range of 500 yards and at every 300 feet for the ranges of 1,000 and 1,500 yards, to a convenient distorted scale.

The constants on which this data will be based, derived from my report to Chief of Ordnance, dated July 17, 1894, are as follows:

For service bullet: V=2,000 foot seconds; w=220 grains; d=0.308″; c=0.88583; C=0.37400.

For tubular bullet: V=3,000 foot seconds; w=104 grains; $\sqrt{D^2-d^2}$ =0.28489; c=0.55491; C=0.32988.

Respectfully,

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

Lieut. RUGGLES.

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Steel tubular bullet.

500 yards.		1,000 yards.		1,500 yards.	
V 3,000 f. s.	v = 1,580.4 f. s.	V = 3,000 f. s.	v = 939.7 f. s.	V = 3,000 f. s.	v = 708 f.
ϕ 15′ 22″.	ω = 22′ 16″.	ϕ = 52′ 33″.	ω = 1° 50′ 30″.	ϕ = 2° 8′.	ω = 4° 51′
x 100 feet.	y = .31878 feet.	x = 300 feet.	y = 4.25856 feet.	x = 300 feet.	y = 10.845
x = 200 feet.	y = .6751 feet.	x = 600 feet.	y = 7.97952 feet.	x = 600 feet.	y = 21.152
x = 300 feet.	y = 1.01401 feet.	x = 900 feet.	y = 11.6535 feet.	x = 900 feet.	y = 31.42
x = 400 feet.	y = 1.30885 feet.	x = 1,200 feet.	y = 14.3876 feet.	x = 1,200 feet.	y = 40.74
x = 500 feet.	y = 1.54638 feet.	x = 1,500 feet.	y = 16.2216 feet.	x = 1,500 feet.	y = 49.16
x = 600 feet.	y = 1.73393 feet.	x = 1,800 feet.	y = 16.8901 feet.	x = 1,800 feet.	y = 56.417
x = 700 feet.	y = 1.86153 feet.	x = 2,100 feet.	y = 16.0485 feet.	x = 2,100 feet.	y = 62.16
x = 800 feet.	y = 1.92677 feet.	x = 2,400 feet.	y = 13.2684 feet.	x = 2,400 feet.	y = 65.96
x = 900 feet.	y = 1.92063 feet.	x = 2,700 feet.	y = 8.06352 feet.	x = 2,711 feet.	y = 67.33
x = 1,000 feet.	y = 1.8375 feet.	x = 3,000 feet.	y = 0 feet.	x = 3,000 feet.	y = 65.84
x = 1,100 feet.	y = 1.66867 feet.			x = 3,300 feet.	y = 61.06
x = 1,200 feet.	y = 1.4104 feet.			x = 3,600 feet.	y = 52.63
x = 1,300 feet.	y = 1.11554 feet.			x = 3,900 feet.	y = 39.89
x = 1,400 feet.	y = .58499 feet.			x = 4,200 feet.	y = 22.54
x = 1,500 feet.	y = 0 feet.			x = 4,500 feet.	y = 0 feet.
x_o = 840.765 feet	y_o = 1.93308 feet.	x_o = 1,795.735 feet or 1,800 feet.	y_o = 16.8901 feet.	x_o = 2,701.16 feet.	y_o = 67.33

Steel tubular bullet.

Range for maximum ordinate, 5 feet 9 inches
Range for maximum ordinate, 8 feet

Tubular bullet in service shell.

Total weight of cartridge ..... grains..
Total length of cartridge ..... inches..
Shell, tinned cartridge brass:
  Length ..... inches..
  Weight ..... grains..
Bullet, tubular, vulcanized fiber sabot, copper band, all steel, cigar-shaped:
  Length ..... inches..
  Weight ..... grains..
Sectional density .....
Charge, Leonard, J. ..... grains..
Gas pressure ..... pounds
Recoil energy:
  Free recoil ..... foot pounds..
  Dynamometer ..... do....
Range for maximum ordinate:
  Firing lying down, 5 feet 9 inches ..... yards..
  Firing lying down, 8 feet ..... do....
Penetration in oak against the grain ..... inches..

Service bullet.

500 yards.		1,000 yards.		1,500 yards.	
V = 2,000 f. s.	v = 1.141.8 f. s.	V = 2,000 f. s.	v = 833.0 f. s.	V = 2,000 f. s.	v = 656.5 f.
ϕ = 31° 4′.	ω = 45′ 41″.	ϕ = 1° 35′ 36″.	ω = 2° 44′ 49″.	ϕ = 8° 18′.	ω = 6° 9′ 10
x = 100 feet.	y = .873813 feet.	x = 300 feet.	y = 7.9507 feet.	x = 300 feet.	y = 16.9028
x = 200 feet.	y = 1.665200 feet.	x = 600 feet.	y = 14.9887 feet.	x = 600 feet.	y = 32.8895
x = 300 feet.	y = 2.355140 feet.	x = 900 feet.	y = 20.8779 feet.	x = 900 feet.	y = 47.7270
x = 400 feet.	y = 2.947460 feet.	x = 1,200 feet.	y = 25.3531 feet.	x = 1,200 feet.	y = 61.1460
x = 500 feet.	y = 3.4343 feet.	x = 1,500 feet.	y = 28.418 feet.	x = 1,500 feet.	y = 72.141 fe
x = 600 feet.	y = 3.7981 feet.	x = 1,800 feet.	y = 29.2012 feet.	x = 1,800 feet.	y = 82.089 fe
x = 700 feet.	y = 4.04604 feet.	x = 2,100 feet.	y = 26.2012 feet.	x = 2,100 feet.	y = 88.797 fe
x = 800 feet.	y = 4.14833 feet.	x = 2,400 feet.	y = 20.9677 feet.	x = 2,400 feet.	y = 92.4843
x = 900 feet.	y = 4.09307 feet.	x = 2,700 feet.	y = 12.2768 feet.	x = 2,700 feet.	y = 92.7966
x = 1.000 feet.	y = 3.9014 feet.	x = 3,000 feet.	y = 0.	x = 3,000 feet.	y = 89.3344
x = 1.100 feet.	y = 3.52134 feet.			x = 3,300 feet.	y = 81.519 fe
x = 1,200 feet.	y = 2.9749 feet.			x = 3,600 feet.	y = 69.3447
x = 1,300 feet.	y = 2.20144 feet.			x = 3,900 feet.	y = 52.0698
x = 1,400 feet.	y = 1.2193 feet.			x = 4,200 feet.	y = 29.639 fe
x = 1,500 feet.	y = 0.			x = 4,500 feet.	y = 0.
x_o = 821.42 feet.	y_o = 4.153748 ft.	x_o = 1,703.05 ft.	y_o = 28.5437 feet.	x_o = 2,576.2 ft.	y_o = 93.0757

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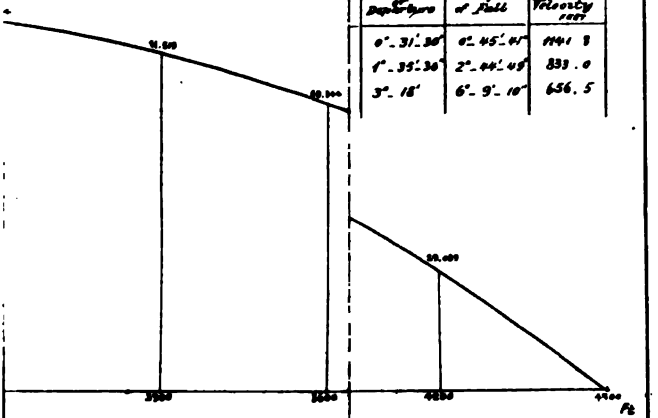
SERVICE BULLET

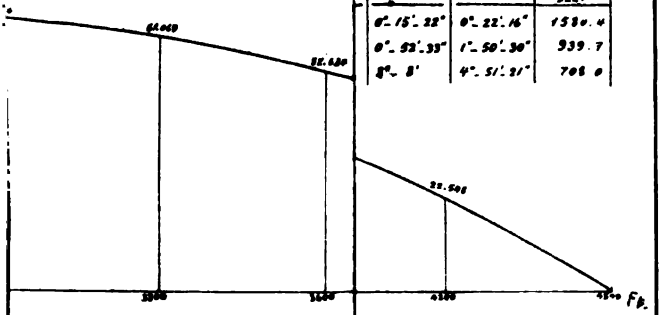
Angle of Departure	Angle of Fall	Final Velocity f.s.e.c.
0°-31'-36"	0°-45'-41"	1141.8
1°-35'-36"	2°-44'-45"	833.0
3°-18'	6°-9'-10"	656.5



0 and 1500 Yards Traject)
cal..30 (U.S. magaz 2000 ft.

TUBULAR BULLET

Angle of Departure	Angle of Fall	Final Velocity f.s.e.c.
0°-15'-22"	0°-22'-16"	1580.4
0°-52'-33"	1°-50'-30"	939.7
3°-8'	4°-51'-21"	708.0



0, 1000 and 1500 Yards Trajected)
ubular Bullet cal..30

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Steel tubular bullet.

500 yards.		1,000 yards.		1,500 yards.	
V = 3,000 f. s.	v = 1,580.4 f. s.	V = 3,000 f. s.	v = 939.7 f. s.	V = 3,000 f. s.	v = 70
ϕ = 15° 22'.	ω = 22° 16'.	ϕ = 52° 33'.	ω = 1° 50' 30".	ϕ = 2° 8'.	ω = 4°
x = 100 feet.	y = .31878 feet.	x = 300 feet.	y = 4.25856 feet.	x = 300 feet.	y = 10
x = 200 feet.	y = .6751 feet.	x = 600 feet.	y = 7.97952 feet.	x = 600 feet.	y = 21.
x = 300 feet.	y = 1.01491 feet.	x = 900 feet.	y = 11.6535 feet.	x = 900 feet.	y = 31.
x = 400 feet.	y = 1.36885 feet.	x = 1,200 feet.	y = 14.3876 feet.	x = 1,500 feet.	y = 40.
x = 500 feet.	y = 1.54638 feet.	x = 1,500 feet.	y = 16.2216 feet.	x = 1,500 feet.	y = 48.
x = 600 feet.	y = 1.77391 feet.	x = 1,800 feet.	y = 16.8901 feet.	x = 1,800 feet.	y = 56.
x = 700 feet.	y = 1.86153 feet.	x = 2,100 feet.	y = 16.0485 feet.	x = 2,100 feet.	y = 62.
x = 800 feet.	y = 1.92677 feet.	x = 2,400 feet.	y = 13.2884 feet.	x = 2,400 feet.	y = 65.
x = 900 feet.	y = 1.89463 feet.	x = 2,700 feet.	y = 8.06352 feet.	x = 2,711 feet.	y = 67.
x = 1,000 feet.	y = 1.8373 feet.	x = 3,000 feet.	y = 0 feet.	x = 3,000 feet.	y = 65.
x = 1,100 feet.	y = 1.66867 feet.			x = 3,300 feet.	y = 61.
x = 1,200 feet.	y = 1.4104 feet.			x = 3,600 feet.	y = 52.
x = 1,300 feet.	y = 1.11334 feet.			x = 3,900 feet.	y = 39.
x = 1,400 feet.	y = .58490 feet.			x = 4,200 feet.	y = 22.
x = 1,500 feet.	y = 0 feet.			x = 4,500 feet.	y = 0 fe
x_o = 840.765 feet	y_o = 1.92960 feet.	x_o = 1,795.735 feet or 1,800 feet.	y_o = 16.8901 feet.	x_o = 2,701.16 feet.	y_o = 67.

Steel tubular bullet.

Range for maximum ordinate, 5 feet 9 inches.....
Range for maximum ordinate, 6 feet.....

Tubular bullet in service shell.

Total weight of cartridge ..... grains...
Total length of cartridge ..... inches...
Shell, tinned cartridge brass.
Length ..... inches...
Weight ..... grains...
Bullet, tubular, vulcanized fiber sabot, copper band, all steel, cigar-shaped:
Length ..... inches...
Weight ..... grains...
Sectional density .....
Charge, Lesmark .....
Gas pressure ..... pounds...
Recoil energy
Free recoil ..... foot pounds...
Transmitted ..... do.....
Range for maximum ordinate
Firing [illegible] feet 9 inches ..... yards...
Firing [illegible] feet ..... do.....
Penetration in oak against the grain ..... inches...

Service bullet.

[illegible] yards.		[illegible] yards.		[illegible] yards.	
V = [illegible]	v = [illegible]	V = [illegible]	v = [illegible]	V = [illegible]	v = 856.3 f.
ϕ = [illegible]	ω = [illegible]	ϕ = [illegible]	ω = [illegible]	ϕ = [illegible]	ω = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]	x = [illegible]	y = [illegible]
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x = [illegible]	y = [illegible]			x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]			x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]			x = [illegible]	y = [illegible]
x = [illegible]	y = [illegible]			x = [illegible]	y = [illegible]
x_o = [illegible]	y_o = [illegible]	x_o = [illegible]	y_o = [illegible]	x_o = [illegible]	y_o = [illegible]

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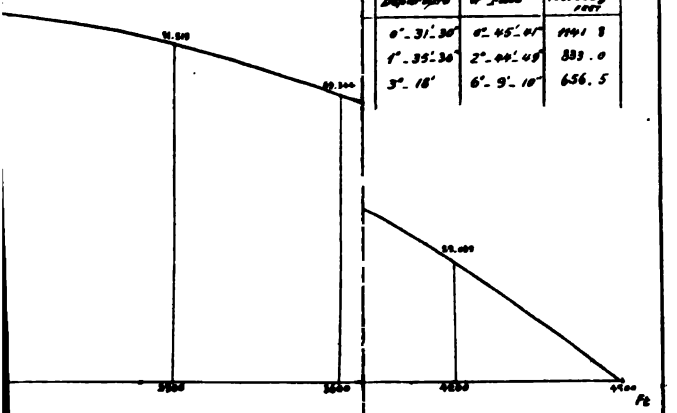
SERVICE BULLET

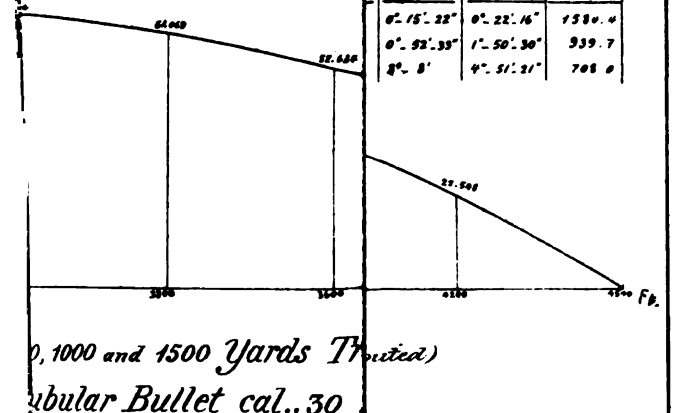
Angle of Departure	Angle of Fall	Final Velocity f.s.e.c.
0°-31'-36"	0°-45'-01"	1141.8
1°-35'-36"	2°-44'-48"	883.0
3°-18'	6°-9'-10"	656.5



...o and 1500 Yards Traje...)
...t cal..30 (U.S. magaz... 2000 ft.

TUBULAR BULLET

Angle of Departure	Angle of Fall	Final Velocity f.s.e.c.
0°-15'-22"	0°-22'-16"	1380.4
0°-52'-33"	1°-50'-30"	939.7
3°-8'	4°-51'-21"	708.0



...0, 1000 and 1500 Yards Tr...ted)
...ubular Bullet cal..30 ...

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Service bullet.

	Yards.
Range for maximum ordinate, 5 feet 9 inches, firing lying down	565.53
Range for maximum ordinate, 8 feet, firing lying down	638.58

Service cartridge.

Total weight of cartridge	grains	412 to 413
Total length of cartridge	inches	3.08 to 3.089
Shell, tinned cartridge brass:		
Length	do	2.315
Weight	grains	150
Bullet, jacket material, cupro-nickeled steel, length	inches	1.265
Shape, cylindro-conical, ogival head, flat base:		
Weight	grains	220
Sectional density		.3313015
Charge, Peyton powder	grains	43 ±
Gas pressure	pounds	33,000 ±
Recoil energy:		
Free recoil	foot pounds	11.35088
Dynamometer	do	5.5
Range for maximum ordinate (yards):		
Firing lying down, 5 feet 9 inches	yards	565.53
Firing lying down, 8 feet	do	638.58
Penetration, in well-seasoned oak, against grain	inches	16.5

COLDEN L'H. RUGGLES,
First Lieutenant of Ordnance.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 4, 1894.

Approved and respectfully forwarded to the Chief of Ordnance, U. S. Army, in connection with my reports of March 30 and July 17, 1894, upon experiments with service and tubular bullets, caliber .30, at this arsenal.

J. P. FARLEY,
Lieutenant-Colonel of Ordnance, Commanding.

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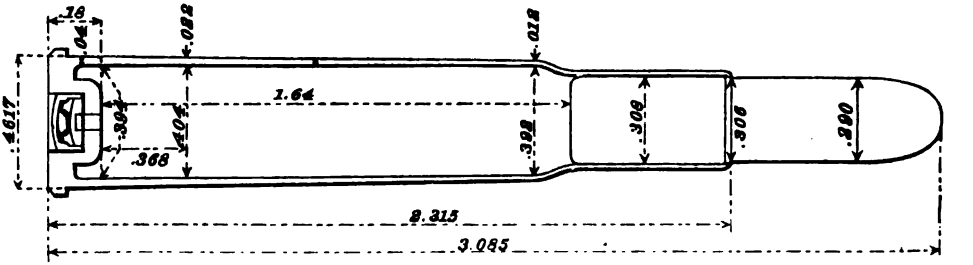
APPENDIX 8.

SPECIFICATIONS FOR SMOKELESS POWDER FOR .30-CALIBER SMALL ARMS.

The powder shall be subject to proof firing in the United States .30-caliber magazine rifle, model 1892,* and in the .30-caliber pressure gauge used at the Frankford Arsenal, with the service .30-caliber cartridge case and 220-grain bullet. The dimensions of the assembled cartridge one and one-half times enlarged are shown in the following figure. The space in which the powder charge is contained is 0.207 of a cubic inch.

Fig. 1.



The weight of the powder charge is not prescribed, but will be governed by the ballistic requirements, the nature of the powder, and the results of preliminary firings made in the proof of the powder delivered under the contract at the Frankford Arsenal. It is desirable that the charge shall fill the powder space and allow the bullet to be seated on the powder without compression.

The powder will be tested for acceptance on delivery at the Frankford Arsenal, and for this purpose shall be divided in lots of 500 pounds (5 barrels); each lot, at the option of the Department, to be proved and tested by firing charges of the determined weight, under the following conditions:

ORDINARY TESTS.

The powder being taken as received and under the ordinary conditions governing the loading of a service powder:

a. The mean velocity, measured at 53 feet from the muzzle, must be not less than 1,960 foot seconds, and the mean variation of velocity must not exceed 20 foot seconds. The proof for the first lot of each invoice to comprise forty consecutive rounds fired from the .30-caliber rifle.

The mean velocity thus established for the first lot shall be taken as the standard velocity of the invoice. The proof of lots in each invoice

* The following dimensions are given: Total length of barrel, 30 inches; travel of projectile in bore, 28.19 inches (94 calibers); diameter of bore within the lands, 0.30 inch. The rifling consists of four plain grooves with width three times that of the lands and 0.004 inch deep; twist uniform, one turn in 10 inches.

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subsequent to the first, to comprise twenty consecutive rounds in which the mean velocity must in no case vary by more than 20 foot seconds from that determined from an equal number of rounds from the first lot of 500 pounds, loaded and fired under similar conditions for comparison.

b. The maximum pressure measured by the gauge must not exceed 38,000 pounds per square inch, the proof to comprise ten consecutive rounds fired from the pressure gauge.

SPECIAL TESTS.

1. Samples of the powder sufficient to load at least 20 cartridges will be subjected to treatment as follows:

Heat.—Exposed for twenty-four hours to a temperature of 130° F.

Moisture.—Exposed for twenty-four hours over water in a closed vessel.

Dryness.—(*a*) Exposed for twenty-four hours freely to the atmosphere.

(*b*) Exposed for twenty-four hours over water in a closed vessel and then for twenty-four hours freely to the atmosphere.

Cold.—Exposed for four periods of six hours each to a temperature of from 35 to 40° below zero, Fahrenheit, in the Frankford Arsenal refrigerating apparatus, and exposure to air for 24 hours to evaporate condensed moisture.

Each sample, following the specified treatment, will be loaded into cartridges and tested as follows:

The mean velocity must in no case vary by more than 100 foot seconds from the standard already determined; the mean variation in velocity must not exceed 30 foot seconds, and the maximum pressure must not exceed 45,000 pounds per square inch; the proof to comprise ten consecutive rounds fired, as before, from the .30-caliber rifle and from the pressure gauge, respectively.

2. Lots of not less than 10 cartridges in each will be loaded with the determined charge and then subjected to treatment as follows:

Heat.—Exposed for twenty-four hours to a temperature of 130° F.

Moisture.—Exposed for one week over water in a closed vessel.

Cold.—Exposed for four periods of six hours each to a temperature of from 35 to 40° below zero, Fahrenheit, in the Frankford Arsenal refrigerating apparatus.

Stability.—The powder to withstand for at least 15 minutes a temperature of 150° to 154° F. without emitting acid vapors, as indicated by the slightest discoloration of a piece of iodide of potassium starch paper partially moistened with dilute glycerin.

Each lot of cartridges, following the specified treatment, will be tested as follows:

The mean velocity must in no case vary by more than 100 foot seconds from the standard already determined, and the mean variation in velocity must not exceed 30 foot seconds, and the pressure 45,000 pounds per square inch, the proof to comprise ten consecutive rounds fired from the .30-caliber rifle and five from the pressure gauge.

The powder charges used in these ordinary and special tests will be separately weighed and hand-loaded.

The powder must be uniform in quality, free from dust and other foreign substances, subject to inspection by the Ordnance Department. Other qualities, in regard to which such additional tests will be made as the Department may deem necessary, are required, as follows:

1. The powder must be practically smokeless;
2. It must not corrode the barrel or cartridge case;

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3. It must not require an unduly strong primer for ignition;

4. It must not leave a hard adherent residue in the bore, especially after rapid firing, nor a metallic residue due to action of heat on bullet or barrel;

5. It must not be sensitive to friction, or shock;

6. It must not be so friable as to endanger breakage of grains in transportation incident to service;

7. It must not contain ingredients known to be unsuited to form a safe and reasonably stable compound;

8. It must admit of machine-loading, with the machines in use or that can be readily provided at the Frankford Arsenal, not exceeding a variation of 0.3 of a grain from the desired charge in 50 consecutive machine-loaded charges.

Other things being equal, that powder which produces the least heating of the barrel will be preferred.

The powder must be packed in metallic barrels, with 5-inch screw opening in one head, similar to the standard service pattern, containing 100 pounds each, the contents of each barrel inclosed in a suitable bag. Powder barrels to be marked "Smokeless Powder for .30-caliber Small Arms."

Samples of the powder accepted under contract will be at once taken by the Department and subjected to a test of continued storage under trying climatic conditions. The results of such tests will be considered of great importance by the Department in placing future orders.

Responsible parties proposing to bid will be furnished upon application with samples of the cartridge case and bullet shown in fig. 1. Bidders will state in their proposals the weight in grains of their powder, which without compression will fill the powder space, and also will state, as nearly as may be practicable, the weight of charge which they propose as suited to fulfill the ballistic requirements herein stated.

Parties proposing to bid are invited to submit samples of their powder for test to the commanding officer of the Frankford Arsenal prior to the date set for the opening of bids in the advertisement, particularly in cases where tests of the same powder have not been previously made at that arsenal.

The successful bidder may at any time after the contract is awarded submit for test samples of the powder he proposes to furnish, provided that such tests shall in no way delay the delivery of the powder as originally agreed upon.

Preference will be given to powder of American manufacture.

Preference will also be given to powder which does not contain nitroglycerin as an ingredient. If the powder contains nitroglycerin bidders will state in what proportion this ingredient is used.

Blank forms on which proposals must be made can be had upon application to this office.

Bidders will state the price per pound for the powder delivered at the Frankford Arsenal, Pa., and when deliveries can begin, and how soon the whole quantity can be delivered.

The Department reserves the right to reject any or all bids or parts thereof.

Envelopes containing proposals should be marked "Proposals for Powder," and addressed to the Chief of Ordnance, U. S. Army, Washington, D. C.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance, U. S. Army.

ORDNANCE OFFICE, WAR DEPARTMENT,
November 4, 1893.

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APPENDIX 9.

REPORTS OF TESTS OF SMOKELESS POWDER FOR SMALL ARMS, BY BOARD OF OFFICERS, FRANKFORD ARSENAL, PENNSYLVANIA, LIEUT. COL. J. P. FARLEY, COMMANDING.

I. Samples of Peyton powder for .30-caliber magazine rifle.
II. Samples of Leonard powder for .30-caliber magazine rifle.
III. Sample of Troisdorf powder for .30-caliber magazine rifle.
IV. Sample of Tschirner smokeless (explosive) powder.
V. Sample of Walsrode powder for .30-caliber magazine rifle.
VI. Sample of Walsrode powder for .45-caliber Springfield rifle.
VII. Sample of Rifleite powder for .45-caliber Springfield rifle.

I.—PEYTON POWDER, GLAZED AND UNGLAZED, .30-CALIBER.

Twenty pounds of machine-made smokeless powder submitted by Bernard Peyton, for the California Powder Works, Santa Cruz, Cal., was referred to the board by indorsement on letter from Bernard Peyton to the Chief of Ordnance, U. S. Army, dated July 22, 1893.

Three pounds of powder similar to the above, but unglazed, was afterwards referred to the board for test by indorsement dated August 9, 1893, on letter of Bernard Peyton to the Chief of Ordnance, U. S. Army, dated July 29, 1893.

The tests were carried on as expeditiously as possible at such times as the members of the board could be spared from their other duties, at least one member of the board being present at every test.

Journal of tests.

Date.	Gun.	Number of shots.	Powder charge.		Projectile.		Velocity of bullet 58 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.
			Kind.	Weight.	Jacket.	Weight.					
				Grs.		*Grs.*	*Ft. secs.*	*F. secs.*	*F. secs.*	*Lbs.*	*Lbs.*
Aug. 29	F *.....	10	Peyton glazed.	34	German silver.	220	1,945	48	12.6	.....	.....
29	.30-caliber pressure.	10	...do	34	...do	220	1,921	42	14.8	34,000	35,500
27	F *.....	10	...do	35	...do	220	1,983	51	13.6	.....	.....
27	.30-caliber pressure.	10	...do	35	...do	220	1,991	60	21.6	35,000	38,000
31	F *.....	10	...do	36	...do	220	2,096	42	17.6	.....	.....
31	.30 caliber pressure.	10	...do	36	...do	220	2,027	74	19.8	38,000	39,500
31	F *.....	10	...do	37	...do	220	2,127	55	13.2	.....	.....
31	.30 caliber pressure.	10	...do	37	...do	220	2,049	34	9.9	40,000	42,000
30	F *.....	10	Peyton unglazed.	35	...do	220	1,949	58	13.8	.....	.....
30	.30 caliber pressure.	10	...do	35	...do	220	1,883	49	8.7	30,000	32,000
30	F *.....	10	...do	36	...do	220	2,022	103	20.8	.....	.....
30	.30 caliber pressure.	10	...do	36	...do	220	1,926	50	11.7	32,000	35,000
31	F *.....	10	...do	37	...do	220	2,051	63	16.3	.....	.....
31	.30 caliber pressure.	10	...do	37	...do	220	1,932	81	14.5	34,000	35,000
31	F *.....	10	...do	38	...do	220	2,117	54	12.1	.....	.....
31	.30 caliber pressure.	10	...do	38	...do	220	2,049	88	12.8	36,000	39,000
Sept. 1	F *.....	10	...do	39	...do	220	2,098	47	12.5	.....	.....
1	.30 caliber pressure.	10	...do	39	...do	220	2,060	38	12.7	38,000	42,000

* Experimental Springfield rifle, caliber .30.

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The pressure rifle has been in constant use here for several years and on examination recently showed degradation of the barrel, perhaps due to erosion. As appears above, the velocities obtained with it were in some cases much less than with gun "F."

The results of the preceding tests are rather irregular, but generally show good uniformity of velocity, and the pressures obtained are low for the corresponding velocities. On the whole a slight superiority for the unglazed powder is indicated.

The strong primers, weight of pellet .4 and .5 grain, exploded the glazed powder without difficulty. Occasional missfires and hang-fires occurred when the .25-grain pellet primer was used. This primer exploded the unglazed powder satisfactorily.

Both varieties of powder loaded fairly well in the loading machine, the greatest variation for 25 charges being .4 grain for the unglazed and .6 grain for the glazed.

Further experiments were suspended pending the completion of the refrigerating apparatus. The tests were resumed on October 19, with the following results. The new .30-caliber pressure rifle having the same barrel as the new service .30-caliber magazine rifle, was used. Though the barrel of this gun is shorter than those of the rifles previously used the velocities obtained, as will be seen, were greater, the pressures increasing correspondingly.

Thirty-four and 36 grains were the charges selected for the glazed and unglazed powder, respectively, as being the most suitable from the results of previous firings. The velocities and pressures were, however, greater than was anticipated.

New .30-caliber pressure rifle.

Date.	Number of shots.	Powder charge. Kind.	Powder charge. Weight.	Projectile. Jacket.	Projectile. Weight.	Velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.	Remarks.
			Grs.		*Grs.*	*F. secs.*	*F. secs.*	*F. secs.*	*Lbs.*	*Lbs.*	
Oct. 19	10	Peyton unglazed.	36	German silver.	220	2,062	34	7.4	33,000	39,500	Powder under ordinary conditions.
19	10	...do....	36	...do....	220	2,050	36	9.5	33,000	39,000	Powder exposed to moisture 24 hours, and air dried for 24 hours.
19	10	...do....	36	...do....	220	2,062	66	15.5	33,000	39,500	
19	10	...do....	36	...do....	220	2,035	70	16.2	33,000	37,000	Powder exposed to moisture for 24 hours.
19	10	...do....	36	...do....	220	2,068	43	13.6	33,000	40,000	Powder exposed to temperature of 130° F. for 24 hours.
21	10	Peyton glazed.	34	...do....	220	2,042	74	17.4	37,000	39,000	Powder under ordinary conditions.
21	10	...do....	34	...do....	220	2,015	46	13.2	36,000	36,500	Powder exposed to moisture 24 hours.
21	10	...do....	34	...do....	220	2,031	61	15.7	37,000	39,000	Exposed to heat 24 hours (temperature 130° F.).
21	10	...do....	34	...do....	220	2,032	86	17.3	37,000	40,000	Powder air dried for 24 hours.
21	10	...do....	34	...do....	220	2,026	54	11.0	36,000	37,000	Powder exposed to moisture for 24 hours, and air dried for 24 hours.

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For both the glazed and the unglazed powders the above tests developed little change in the velocities and pressures, the greatest being due to exposure to moisture, and this involved a reduction of not more than 2,500 pounds per square inch pressure and not more than 30 foot seconds in velocity.

Owing to an accident to the refrigerating apparatus, the test for exposure to low temperatures had to be again postponed, and will be submitted as a supplementary report. CHARLES H. CLARK,

J. W. BENÉT, *Captain, Ordnance Department.*
First Lieutenant, Ordnance Department, Recorder.

FRANKFORD ARSENAL,
Philadelphia, Pa., November 11, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army, approved. J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

II.—LEONARD POWDERS, .30 CALIBER.

FRANKFORD ARSENAL, PA., *July 31, 1893.*

The board met pursuant to the foregoing orders and instructions. Present: Both the members. Mr. Mason E. Leonard and Lieut. G. N. Whistler, representing the Leonard Smokeless Powder Company, appeared before the board and submitted four samples of small arm smokeless powder, denominated, respectively, N large grain, N fine grain, J large grain and J fine grain.

The fine-grain powders are understood to be substantially the same as those of the same name previously tested here but differ as to the color, which is now more of a reddish hue.

The large-grain powders differ only in the size of the grain from the fine grained powders of the same name. The following preliminary firings were made in the presence of the representatives of the company:

Thirty-caliber pressure gun, July 31.

Number of shots.	Powder charge. Kind.	Powder charge. Weight.	Projectile. Kind.	Projectile. Weight.	Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.
		Grs.		*Grs.*	*Ft. secs.*	*Ft. sec.*	*Ft. sec.*	*Pounds.*	*Pounds.*
2	Leonard, sample N, fine grain	32	German silver.	220	1,974	*	*	30,000	34,000
2	do	33	do	220	1,994	2	1	34,000	35,000
2	do	34	do	220	2,016	12	6	36,000	†35,000
2	do	35	do	220	2,018	48	24	39,000	†40,000
1	do	37	do	220	2,150			46,000	†46,000
1	do	38	do	220	2,225			46,000	†46,000
3	do	40	do	220	2,274	28	11	41,500	44,000
1	do	41	do	220	2,294			42,000	49,000
2	Leonard, sample N, large grain	33	do	220	1,918	0	0	30,000	34,000
2	do	35	do	220	2,216	7	4	43,000	46,000
2	Leonard, sample J, fine grain	30	do	220	2,025	22	11	33,000	34,000
2	do	31	do	220	2,118	45	23	38,000	41,000
1	Leonard, sample J, large grain	29	do	220	1,970			30,000	33,000
2	do	30	do	220	2,001	22	11	33,000	34,000
2	do	31	do	220	2,071	46	23	35,000	36,000
1	do	32	do	220	2,145			37,500	39,000
1	do	33	do	220	2,165			39,000	41,000
1	do	34	do	220	2,197			41,000	43,000

* One velocity lost. † Under.

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After this preliminary test the regular tests were proceeded with from time to time as the other work of the post would permit, at least one member of the board being present at every test.

Sample N, fine grain, was first taken up and various charges were fired for velocity and pressure as follows:

Date.	Gun.	Number of shots.	Powder charge.		Projectile.		Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.
			Kind.	Weight.	Jacket.	Weight.					
				Grs.		*Grs.*		*Ft. sec.*	*Ft. sec.*	*Pounds.*	*Pounds.*
Aug. 15	F*	20	Leonard, sample N, fine grain	33	German silver.	220	2,011	42	10.9	.....	.....
15	Caliber .30 pressure.	15	...do	33	...do	220	1,988	72	13.2	29,000	31,000
16	F*	20	...do	34	...do	220	2,052	52	8.9	.....	.....
16	Caliber .30 pressure.	20	...do	34	...do	220	2,045	56	15.2	30,000	33,000
17	F*	20	...do	35	...do	220	2,091	54	10.4	.....	.....
17	Caliber .30 pressure.	20	...do	35	...do	220	2,067	61	12	33,000	34,500
18	F*	20	...do	36	...do	220	2,127	49	13.7	.....	.....
18	Caliber .30 pressure.	20	...do	36	...do	220	2,101	52	12.4	35,000	36,000
19	F*	†20	...do	37	...do	220	2,145	48	11.2	.....	.....
19	Caliber .30 pressure.	20	...do	37	...do	220	2,130	60	14.2	36,000	39,000
21	F*	†20	...do	38	...do	220	2,180	40	8.8	.....	.....
21	Caliber .30 pressure.	20	...do	38	...do	220	2,167	35	10.5	38,000	39,000
28	F*	‡20	...do	39	...do	220	2,247	46	10	.....	.....
28	Caliber .30 pressure.	20	...do	39	...do	220	2,215	35	9.4	40,000	41,500

* Experimental Springfield rifle, caliber .30.
† Four bullets stripped their jackets and missed second target.
‡ Two bullets stripped their jackets and missed second target.

These results are excellent, the uniformity of velocity being good and the pressures in every case low for the velocities developed. With velocities above 2,100 foot seconds a number of bullets stripped their jackets when fired in Experimental Springfield .30-caliber rifle F. No stripping took place in the pressure gun with the same velocities.

Further tests were postponed pending the procurement of a suitable refrigerating apparatus at the chemical laboratory for carrying out the tests of exposure of the powder to low temperatures. On October 11, the test of the N, fine grain, sample was resumed with the following results; a charge of 33 grains being selected as indicated by the preceding tests to be the most suitable:

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[Powder charge, Leonard, sample N, fine grain. Projectile jacket, German silver.]

Date.	Gun.	Number of shots.	Powder charge (weight).	Projectile (weight).	Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.	Remarks.
			Grs.	*Grs.*		*Ft.sec.*	*Ft.sec.*	*Lbs.*	*Lbs.*	
Oct. 11	F.*	10	33	220	1,906	93	22.7	.....	.....	Powder exposed to moisture for 24 hours.
11	....do	10	33	220	1,985	29	9.9	.....	.....	Powder exposed to temperature of 128° to 130° 24 hours.
11	....do	10	33	220	1,964	40	11.3	.....	.....	Powder exposed to moisture 24 hours and air-dried 24 hours.
11	..do	10	33	220	1,976	19	5.9	.....	.....	Powder exposed to ordinary conditions of loading.
14	liber .30-pressure rifle.	10	33	220	1,901	45	14.8	29,000	†29,000	Powder exposed to moisture for 24 hours.
14	.do	10	33	220	1,912	36	8.4	29,000	30,000	Powder exposed to temperature of 128° to 130° 24 hours.
14	do	10	33	220	1,925	34	10.2	29,000	30,000	Powder exposed to moisture 24 hours and air-dried 24 hours.
14	do	10	33	220	1,938	75	19.6	29,000	30,000	Powder exposed to ordinary conditions of loading.

* Experimental Springfield. † Under.

The pressures and velocities were slightly affected by the moisture test, the loss of velocity amounting to 70 foot seconds in one case. The other tests gave no material change. The test of the J, fine grain, sample gave the following results:

[Powder charge, Leonard, J, fine grain. Projectile jacket, German silver. Primer with 0.5 grain pellet used.]

NEW .30-CALIBER PRESSURE RIFLE, NOVEMBER 6.

Number of shots.	Powder charge (weight).	Projectile (weight).	Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Lbs.*	*Lbs.*	
10	29	220	1,966	42	13.4	35,000	36,000	A_4 primer used; weight of pellet 0.4 grain.
10	30	220	2,023	80	26	36,000	37,500	
10	31	220	2,061	56	12.1	37,000	38,500	Two miss-fires; primer ignited, but did not explode powder.
10	32	220	2,120	54	13.5	39,000	43,500	Two hang-fires, one miss-fire; primer ignited, but did not explode powder.

OLD .30-CALIBER PRESSURE RIFLE, OCTOBER 9.

5	30	220	1,840	28	7.6	35,000	†35,000	Powder exposed to moisture for 24 hours.
10	30	220	1,974	32	8.6	35,000	36,000	Powder exposed to temperature 130° for 24 hours.
10	30	220	1,973	66	19	35,000	36,500	Powder exposed to moisture 24 hours and air-dried 24 hours.
10	30	220	1,979	40	12.8	35,000	37,000	Powder exposed to ordinary conditions.

* Under.

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[Powder charge, Leonard, J, fine grain. Projectile jacket. German silver. Primer with 0.5 grain pellet used.]

GUN F, AN EXPERIMENTAL SPRINGFIELD .30-CALIBER RIFLE, OCTOBER 9.

Number of shots.	Powder charge (weight).	Projectile (weight).	Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.	Remarks.
	Grains.	*Grains.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Lbs.*	*Lbs.*	
10	30	220	1,823	94	26.4	.....	.....	Powder exposed to moisture for 24 hours.
10	30	220	1,971	125	23.3	.....	.....	Powder exposed to heat for 24 hours.
10	30	220	1,950	22	8.5	.....	.....	Powder exposed to moisture 24 hours and air-dried 24 hours.
10	30	220	1,958	84	19.3	.....	.....	Powder exposed to ordinary conditions.

The sample J, fine grain, except in the case of the 30-grain charge, gave good uniformity of velocity, and the pressures, though higher than those given by the N, fine grain, sample for the same velocities, are still very moderate.

The powder is hard to explode with the A_4 primer, weight of pellet .4 grain, directed to be used in future tests by the commanding officer, Frankford Arsenal. The primer with .5 grain pellet served to explode it without difficulty in the tests for variations of temperature. Exposure to moisture decreased the velocity of the powder by over 100 foot seconds with a corresponding reduction of pressure.

The other tests did not seem to affect the ballistic qualities of the powder.

The new pressure rifle having the same barrel as the new service magazine rifle, caliber .30, gave a velocity greater by 45 feet than that obtained in the old pressure rifle and gun F, although the latter have a greater length of barrel. They have both, however, been fired a large number of rounds, and the old pressure rifle barrel shows signs of degradation, perhaps due to erosion.

Owing to the limited amount of samples N, large grain, and J, large grain, it was impossible to carry out the tests for variations of temperature. The samples were fired for pressure and velocity with the following result:

NEW PRESSURE RIFLE, .30 CALIBER, NOVEMBER 8.

Number of shots.	Powder charge.		Projectile.		Mean velocity of bullet 53 feet from muzzle.	Extreme variation.	Mean variation.	Initial compression per square inch.	Final compression per square inch.	Remarks.
	Kind.	Weight.	Jacket.	Weight.						
		Grs.		*Grs.*	*Ft. sec.*	*Ft. sec.*	*Ft. sec.*	*Lbs.*	*Lbs.*	
10	Leonard, N, large grain.	33	German silver.	220	1,934	47	10.7	29,000	31,000	
10	....do	34	...do	220	1,966	48	14.9	31,000	32,500	
10	....do	35	...do	220	2,020	42	13.2	32,000	35,000	
10	....do	36	...do	220	2,066	73	17.5	34,000	37,000	Primer A_4 used; weight of pellet 0.4 grain.
10	Leonard, J, large grain.	30	...do	220	1,998	26	9.5	33,000	36,000	1 miss and 2 hang fires; primer ignited, but did not explode powder.
10	....do	31	...do	220	2,026	53	16.3	34,000	38,500	1 hang-fire.
10	....do	32	...do	220	2,085	53	12.3	37,000	39,500	2 miss and 1 hang fire; primer ignited, but did not explode powder.
10	....do	33	...do	220	2,134	49	13.4	39,000	43,000	2 hang fires.

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The uniformity of velocity obtained with both samples is excellent. The N, large grain, gives lower pressure for the same velocities.

The same difficulty was experienced with the large grain as with the fine grain J powder as regards exploding it with the A_4 primer; weight of pellet 0.4 grain.

For a velocity at 53 feet from the muzzle of about 1,960 foot seconds, we have for the four samples submitted:

	Charge.	Velocity.	Pressure per square inch.
	Grains.	*Ft. secs.*	*Pounds.*
N, fine grain	33	1,988	31,000
N, large grain	34	1,966	32,500
J, fine grain	29	1,966	36,000
J, large grain	30	1,998	36,000

and for a pressure of about 38,000 pounds per square inch:

	Charge.	Velocity.	Pressure per square inch.
	Grains.	*Ft. secs.*	*Pounds.*
N, fine grain	36	2,101	36,000
N, large grain	36	2,066	37,000
J, fine grain	31	2,023	37,500
J, large grain	31	2,026	38,500

The amount of the large grain samples remaining was not sufficient to test machine loading. Sample N, fine grain, did not load satisfactorily in the machine, as the powder would not flow freely, and distributed a portion of the charge on the machine head between the successive dies. J, fine grain, loaded without difficulty, the extreme variation in weight of 20 charges of 42 grains being 1.1 grains. In order to avoid making new dies a charge of 42 grains had to be taken.

The refrigerating apparatus was working satisfactorily when the tests for variations of temperature were commenced, but afterwards some defects were developed which are being corrected, and in obedience to verbal instructions from the commanding officer, Frankford Arsenal, the present report is rendered at this time, reserving the test for exposure to low temperatures for a supplementary report, to be submitted as soon as practicable.

CHARLES H. CLARK,
Captain of Ordnance.

J. W. BENÉT,
First Lieutenant, Ordnance Department, Recorder.

FRANKFORD ARSENAL,
Philadelphia, Pa., November 13, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army, approved.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

III.—TROISDORF POWDER, .30 CALIBER.

FRANKFORD ARSENAL,
Philadelphia, Pa., January 25, 1894.

SIR: The following report is respectfully submitted of tests made with sample of Troisdorf powder received November 29, 1893, from Mr.

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F. W. Groos, American agent. This powder resembles in color and size of grain the Troisdorf powder previously reported upon.

The sample submitted was not sufficient for complete tests, and the board has in consequence been limited to those which it thought of the most importance. The general character of tests made corresponded with the specifications recently published in the advertisement for bids for smokeless powders. The E_4 primer was used throughout the tests and there were no missfires or hang fires.

In determining the proper charge some difficulty was experienced, due to the considerable variation in velocity (98 foot seconds) between the pressure gun and experimental rifle, with the same weight of charge. The board was unable to account satisfactorily for this difference, the two barrels corresponding in length and rifling.

It was finally decided to assume that the pressures with this powder were proportional to velocities, and to use such charge with each arm as would give most nearly the standard velocity. Preliminary firing indicated the proper charges to be 34 grains in the pressure barrel and 36 in the rifle. Accompanying is a tabulated statement of the results, together with a summary (A) of the results of exposure of the powder to heat, moisture, and cold.

As a velocity of 1,968 foot seconds was obtained with 36 grains in the rifle, it was assumed that the pressure was but little in excess of that corresponding to 34 grains in the pressure barrel, which gave a velocity of 1,953 foot seconds with mean pressure of 38,000 pounds. The pressures with this powder are found to be quite uniform.

A summary (B) of the record of the lot of Troisdorf powder received in October, 1892, has been tabulated and is submitted for purposes of comparison.

It is, however, difficult to draw conclusions from a comparison between results obtained with this powder in May, 1893, and in December, 1893, as the former varied so unaccountably,* and in the latter the conditions as to gun and primer had changed. It is impossible to estimate the allowances to be made for these changes. The first results obtained with charges of 35 grains in the T rifle (1,990.0 velocity) correspond with those of December 8, firing 35 grains in the D rifle, where the velocity obtained was 1,995.3 foot seconds. In the latter case, however, the mean variation was much lower. The board does not consider that the ballistic data is sufficient to warrant a definite statement that the powder has in no degree deteriorated, though this might be inferred from the uniformity of results obtained in the limited firing of December 8, 1893 (B).

That the sample lately received differs in ballistic qualities from the first may be assumed from comparison of the records of December 1 and December 4 (A), and December 8 (B), both with experimental rifle D, and under similar conditions as to primer.

CHARLES H. CLARK,
Captain of Ordnance,
For the Board.

The COMMANDING OFFICER FRANKFORD ARSENAL, PA.

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*The record (Report Book 10, p. 449) does not state whether or not the same primer was used throughout this firing, but the report on primers, same book, pages 21 and 22, shows that the firings of May 26 and May 29 were complicated with differences in primers, anvils, and vents (*see* remarks B).

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FRANKFORD ARSENAL,
Philadelphia, Pa., January 26, 1894.

Respectfully forwarded to the Chief of Ordnance, U. S. Army.

The relief of Lieut. J. W. Benét and assignment of Lieut. C. L'H. Ruggles as member of the board for the tests of smokeless powders has occasioned a change in the constitution of the board during the progress of tests herein reported. For reasons assigned, the report is not as full and complete as desired.

Capt. Pitman states that he will require more time before giving a definite opinion respecting the presence of nitrous acid fumes in this powder, and that probably within a week he will be able to report the result of certain tests now being made in the chemical laboratory. In the meantime he states that there is no apparent change in the sample of No. 1 Troisdorf powder received here September 24, 1892, which has been kept in a bottle since that time. He also states that a sample of the lot marked Troisdorf No. 6, lately sent here by Mr. Groos, November 24, 1893, has been subjected to an exposure to sunlight, under glass, since December 20, 1893. The average maximum temperature, daily, was 89.5° F. and minimum temperature 26.6° F. The powder has lost 1.36 per cent in weight but with no apparent change in the grain.

	Per cent.
The Peyton glazed has lost	1.65
The Peyton unglazed has lost	1.26
The Leonard "J" has lost	2.43
The Leonard "N" has lost	2.56
The Walsrode has lost	0.61
The Rifleite has lost	1.03
The New Wetteren has lost	0.99

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

(311-C-'94)

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A.—*Record of tests of Troisdorf (new) smokeless powder for .30-caliber rifle at Frankford Arsenal, Pa.*

[Sample received November 29, 1893. Bullet, German silver jacket, 220 grains.]

Date.	Gun.	Nature of test.	Powder charge (weight).	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation in velocity.		Initial compression of cylinder per square inch.	Powder pressure per square inch.		Barometer.	Thermometer.	
						Extreme.	Mean.		Mean.	Extreme.		Dry bulb.	Wet bulb.
1893.		Exposure to—	*Grains.*	*No.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*	*Pounds.*	*Inches.*	*Deg.*	*Deg.*
Dec. 7	New pressure	Heat	34	10	1,995.6	126	29.2	*36,000	43,000	45,000			
7*	do	Moisture	34	10	1,818.9	132	24.1	{3. 30,000 7. 28,000}	†30,400	35,000			
7‡	Sp. ex. rifle D	Moisture	36	9	1,902	128	26.3						
9	do	Heat	36	10	2,051.6	60	12.2				30.66	37	37
1894.		Exposure to—											
Jan. 16	Sp. ex. rifle D	Cold	36	5	1,945.6	28	11.2				30	52	49
16	New pressure	Cold	34	5	1,939	28	6.6	36,000	37,000	38,000	30	52	49
		Standard powder.											
1893.													
Dec. 1	New pressure	Powder as received	34	10	1,953	44	14	36,000	38,000	39,000	29.80	45	44
1	Sp. ex. rifle D	do	34	40	1,855	75.4	15.375				29.80	44	43
4	do	do	36	20	1,968	64	13.05				30.20	31	31

* 2 under 30,000; 2 under 28,000. † Under. ‡ Record of 4th shot lost.

Results of exposure as regards velocity and pressure.

	Velocity.	Pressure.
Heat:	*Ft. seconds.*	*Pounds.*
Pressure barrel	42.6 gain	5,000 increase.
Experimental rifle	83.6 gain	
Moisture:		
Pressure barrel	134.1 less	8,000 decrease.
Experimental rifle	66 less	
Cold:		
Pressure barrel	14 less	1,000 decrease.
Experimental rifle	22.4 less	

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B.—*Record of tests of Troisdorf (old) smokeless powder for .30-caliber rifle at Frankford Arsenal, Pa.*

[Lot purchased in October, 1892. Bullet, German silver jacket, 220 grains. Machine loading (charges): Extreme variation, 0.6 grain; mean variation, 0.3 grain.]

Date.	Gun.	Powder charge (weight).	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation in velocity.		Initial compression of cylinder per square inch.	Powder pressure per square inch (mean).
					Extreme.	Mean.		
1893		*Grains.*	*No.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*	*Pounds.*	*Pounds.*
May 26	Sp. ex. rifle T *	35	50	1,990	96	20	.....	.....
26	....do †	35	50	1,899	160	39	.....	.....
29	....do ‡	35	50	1,925	152	34.8	.....	.....
29	....do §	35	50	1,938	107	16.3	.....	.....
	....do	36	10	2,031	54	16.2	.....	.....
May 23	Pressure barrel	35	6	1,905	.....	22	31,500	32,500
23	....do	35	7	1,953	.....	12.6	32,000	34,000
23	....do	35	9	1,917	.....	24	32,000	33,000
23	....do	36	10	2,047	.....	16	34,000	40,000
Dec. 8	Sp. ex. rifle D	34	10	1,957	14	5.7	.....	.....
8	....do	35	10	1,995.3	19	7.3	.....	.....
15	‖	.....	.....	.....	.....	.....	.....	.....

* No. 3 primer, modified anvil and reduced vent; 0.4 grain pellet.
† No. 3 primer, solid anvil and two 0.03" vents; 0.4 grain pellet.
‡ Primer, regular composition; 0.4 grain, modified anvil and reduced vent.
§ Primer, regular composition; 0.4 grain, solid anvil and two 0.03" vents.
‖ 50 charges: Mean, 35.77; highest, 35.9; lowest, 35.3.

IV.—TSCHIRNER POWDER.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 16, 1894.

Proceedings of the Frankford Arsenal board for the test of smokeless powders:

The board met from time to time as circumstances permitted for the purpose of examining and testing the Tschirner smokeless (explosive) powder, pursuant to the second indorsement, Ordnance Office, file No. 115–A, February 12, 1894.

The board finds that the Tschirner smokeless powder is a high explosive, and susceptible of detonation by fulminate of mercury. It is sensitive to percussion. On account of the physical form and properties of this explosive it is not, in the opinion of the board, suitable for use as a smokeless powder and propelling agent.

J. PITMAN,
Captain, Ordnance Department, President.
CHARLES H. CLARK,
Captain, Ordnance Department, Member.
COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, Recorder.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 18, 1894.

Respectfully forwarded to the Chief of Ordnance, U. S. Army. Approved.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

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V.—WALSRODE POWDER, .30 CALIBER.

FRANKFORD ARSENAL,
Philadelphia, Pa., May 31, 1894.

SIR: The board on smokeless powders has the honor to submit herewith the results of the test of Walsrode smokeless power for .30 caliber U. S. magazine rifle.

A complete test could not be made on account of the small amount of powder received.

The required velocity of 1,960 foot seconds could not be obtained without greatly exceeding the allowed limit of pressure.

The charge of 33 grains was fixed upon as the largest charge giving a pressure within the allowed limits.

The mean variations in velocity with this powder are, as a rule, high.

The special tests so far as applied, developed no marked variations from the standard in either pressure or velocity. The stability test of this powder was satisfactory.

J. PITMAN,
Captain, Ordnance Department, President.
CHARLES H. CLARK,
Captain, Ordnance Department, Member.
COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, Recorder.

The COMMANDING OFFICER FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 6, 1894.

Approved and respectfully forwarded to the Chief of Ordnance, U. S. Army.

J. P. FARLEY,
Lieutenant Colonel, Ordnance Department, Commanding.

(827 A–'94)

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Record of tests of Walsrode smokeless powder for .30-caliber U. S. magazine rifle at Frankford Arsenal.

Date.	Gun.	Nature of test.	Powder charge.		German-silver bullet (weight).	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation in velocity.		Variation in velocity from the standard.	Initial compression of cylinder per square inch.	Powder pressure per square inch.		Barometer.	Thermometer.	
			Kind.	Wt.				Extreme.	Mean.			Mean.	Extreme.		Dry bulb.	Wet blub.
1894.				*Grs.*	*Grs.*	*No.*	*Ft. secs.*	*Ft. secs.*	*Ft. secs.*		*Pounds.*	*Pounds.*	*Pounds.*	*Inches.*	*Deg.*	*Deg.*
April 3	Pressure gun No. 3..	To determine charge	Walsrode...	35	220	9	1,926.6	.....	.....	.....	35,071	47,451	53,250	30.36	46	37
3	.....do.....	.....do.....	.....do.....	34	220	5	1,944.4	.....	.....	.....	35,126	41,426	44,000	30.36	46	37
3	U. S. mag. rifle No. 5.	.....do.....	.....do.....	34	220	5	1,927.8	81	25.1	.....	.....	.....	.....	30.36	46	37
3	.....do.....	.....do.....	.....do.....	34	220	10	1,948.7	104.34	15.87	.....	.....	.....	.....	30.35	47	39
13	Pressure gun No. 3..	.....do.....	.....do.....	34	220	10	1,968.4	.....	.....	.....	35,540	46,100	52,800	29.88	56	52
14	.....do.....	.....do.....	.....do.....	33	220	10	1,927.8	.....	.....	.....	36,072	39,094	41,000	29.90	59	53
17	U. S. mag. rifle No. 60	Velocity.....	.....do.....	33	220	40	1,791.4	152	28.1	.....	.....	.....	.....	30.14	69	61
18	.....do.....	Heat (cartridges)...	.....do.....	33	220	10	1,814	78	22.8	17.3	.....	.....	.....	30.23	66	57
18	.....do.....	Standard.....	.....do.....	33	220	10	1,831.3	150	39.9	.....	.....	.....	.....	30.22	66	57
18	Pressure gun No. 3..	Heat (cartridges)...	.....do.....	33	220	5	1,851.6	.....	.....	.....	35,640	36,853	38,166	30.23	69	59
25	U. S. mag. rifle No. 65	Moisture(cartridges)	.....do.....	33	220	10	1,870.2	47	12.26	29.2	.....	.....	.....	30.16	65	57
25	.....do.....	Standard.....	.....do.....	33	220	10	1,841	102	26.26	.....	.....	.....	.....	30.15	64	55
26	Pressure gun No. 3..	Moisture(cartridges)	.....do.....	33	220	5	1,863.6	.....	.....	.....	35,418	36,346	37,460	30.10	71	61
26	.....do.....	Standard.....	.....do.....	33	220	5	1,831.4	.....	.....	.....	35,650	36,020	36,440	30.10	71	61
27	U. S. mag. rifle No. 65	Velocity.....	.....do.....	33	220	25	1,842.3	111	24.6	.....	.....	.....	.....	30.10	66	60
May 14	Pressure gun No. 3..	Cold.....	.....do.....	33	220	10	1,874.3	.....	.....	.....	35,579	36,919	39,630	30.10	71	60
14	.....do.....	Standard.....	.....do.....	33	220	10	1,870.1	.....	.....	.....	35,681	36,625	38,400	30.12	71	59
14	U. S. mag. rifle No. 65	Cold.....	.....do.....	33	220	10	1,825.3	125	34.23	34.9	.....	.....	.....	30.09	71	60
14	.....do.....	Standard.....	.....do.....	33	220	10	1,860.2	60	18.71	.....	.....	.....	.....	30.10	70	60
16	Pressure gun No. 3..	Cold (cartridges)...	.....do.....	33	220	5	1,826.6	.....	.....	.....	35,944	36,366	37,100	29.86	75	64
16	.....do.....	Standard.....	.....do.....	33	220	5	1,859.7	.....	.....	.....	35,066	37,000	39,600	29.85	76	65
16	U. S. mag. rifle No. 65	Cold (cartridges)...	.....do.....	33	220	10	1,795.7	212.5	48.48	26.8	.....	.....	.....	29.86	74	64
16	.....do.....	Standard.....	.....do.....	33	220	10	1,822.5	78	26.55	.....	.....	.....	.....	29.85	73	63

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VI.—Walsrode Powder, .45 Caliber.

Frankford Arsenal,
Philadelphia, Pa., December 26, 1893.

Sir: The board on smokeless powders appointed by post orders, 23 and 34, series of 1893, respectfully submits the following report upon the sample of Walsrode smokeless powder referred to it for test by second indorsement on letter of O. Hesse, agent Wolff Company, Walsrode, Prussia, to the Chief of Ordnance, U. S. Army, Washington, D. C., dated November 14, 1893.

The sample submitted is for use in the .45-caliber service Springfield rifle, and is of the flake variety and of a light-brown color. The grains are not very regular.

It was found that 30.5 grains of this powder would fill our service .45-caliber cartridge case to the seat of the 500-grain bullet.

A charge of 30.5 grains was fired in the .45-caliber service Springfield rifle, using the service 500-grain bullet and the ordinary primer (0.2 grain pellet) for .45-caliber cartridges.

The following results were obtained:

Number of shot.	Mean velocity at 53 feet from muzzle.	Number of shot.	Mean velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,270	9	1,238
2	1,296	10	1,269
3	1,291		
4	1,266	Mean	1,276
5	1,290	Extreme variation	65
6	1,278	Mean variation	15.8
7	1,303		
8	1,257		

The uniformity of velocity secured was not satisfactory.

Mr. Hesse having stated in his letter that strong primers are necessary to give the best results with this powder, the above test was repeated, using the E/4 primer (0.4 grain pellet). Preliminary shots showed that it would be necessary to reduce the charge previously used to keep down the velocity to the limit desired.

[Charge, 28.5 grains Walsrode powder, E/4 primer.]

Number of shot.	Velocity at 53 feet from muzzle.	Number of shot.	Velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,253	9	1,291
2	1,293	10	*1,259
3	1,282		
4	1,283	Mean	1,277
5	1,284	Extreme variation	48
6	*1,245	Mean variation	14.4
7	1,292		
8	1,284		

* Primer pierced.

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The service charge of Du Pont black powder was fired in comparison, with the following results:

[Charge, 68.5 grains Du Pont black powder, .45 caliber primer, 0.2 grain pellet.]

Number of shot.	Velocity at 53 feet from muzzle.	Number of shot.	Velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,284	8	1,283
2	1,286	9	1,273
3	1,279	10	1,278
4	1,276		
5	1,270	Mean	1,279
6	1,283	Extreme variation	16
7	1,277	Mean variation	4.1

Charges of 28.5 grains Walsrode powder, E/4 primer, were fired in the .45-caliber pressure barrel for velocity and pressure, with the following results:

Number of shot.	Velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated, per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,260	20,000	26,000
2	1,270	20,000	27,500
3	1,245	20,000	21,000
4	1,244	20,000	22,000
5	1,259	20,000	27,000

Mean velocity at 53 feet from muzzle	foot seconds	1,256
Extreme variation	do	25
Mean variation	do	8.8
Mean pressure	pounds per square inch	25,000

The service .45-caliber .2-grain primer did not act well with the Walsrode powder in the pressure barrel, not appearing to be strong enough to explode the powder properly under the particular conditions.

Charges of 68.5 grains of standard Du Pont black powder fired in the pressure rifle under the same conditions gave:

Number of shot.	Velocity at 53 feet from muzzle.	Initial compression of pressure cylinders, per square inch.	Pressure indicated, per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,268	20,000	20,500
2	1,232	20,000	21,500
3	1,252	20,000	22,500
4	1,259	20,000	21,500
5	1,278	20,000	22,500

Mean velocity at 53 feet from muzzle	foot seconds	1,258
Extreme variation	do	46
Mean variation	do	12.1
Mean pressure	pounds per square inch	22,000

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The powder was tested for moisture and heat in comparison with the service black powder, with the following results:

[Fired in .45-caliber Springfield rifle. Charge, 28.5 grains Walsrode powder, E 4 primer. Powder exposed for 24 hours to a temperature of 130° F.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Number of shot.	Mean velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,382	7	Lost.
2	1,352	8	1,292
3	1,318		
4	1,344	Mean	1,335
5	1,324	Extreme variation	90
6	1,335	Mean variation	20.5

[Charge, 68.5 grains Du Pont black powder, .45-caliber primer. Exposed for 24 hours to a temperature of 130° F.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Number of shot.	Mean velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,300	8	1,304
2	1,291	9	1,307
3	1,293	10	1,296
4	1,295		
5	1,301	Mean	1,298
6	1,294	Extreme variation	16
7	1,297	Mean variation	4.2

[Charge, 28.5 grains Walsrode powder, E/4 primer. Powder exposed for 24 hours over water in a closed vessel.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Number of shot.	Mean velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,364	8	1,261
2	1,316	9	1,274
3	1,286	10	1,301
4	1,267		
5	1,352	Mean	1,308
6	1,298	Extreme variation	103
7	1,309	Mean variation	23.8

[Charge, 68.5 grains Du Pont black powder .45-caliber primer. Powder exposed for 24 hours over water in a closed vessel.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Number of shot.	Mean velocity at 53 feet from muzzle.
	Ft. secs.		*Ft. secs.*
1	1,260	8	1,237
2	1,245	9	1,240
3	1,262	10	1,257
4	1,257		
5	1,265	Mean	1,251
6	1,251	Extreme variation	28
7	1,237	Mean variation	9.1

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[Fired in .45-caliber pressure rifle. Charge, 28.5 grains Walsrode powder, E/4 primer. Powder exposed for 24 hours to a temperature of 130° F.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,285	20,000	25,000
2	1,187	20,000	22,000
3	1,297	20,000	26,000
4	1,318	20,000	28,000
5	1,294	20,000	24,000

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,276
Extreme variation	131
Mean variation	35.8
Mean pressure, pounds per square inch	25,000

[Charge, 68.5 grains Du Pont powder, .45-caliber primer. Powder exposed for 24 hours to a temperature of 130° F.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,281	20,000	23,500
2	1,301	20,000	23,500
3	1,308	20,000	25,000
4	1,292	20,000	25,000
5	1,302	20,000	24,500

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,297
Extreme variation	27
Mean variation	8.2
Mean pressure, pounds per square inch	24,500

[Charge, 28.5 grains Walsrode powder, E/4 primer. Powder exposed for 24 hours over water in a closed vessel.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,278		
2	1,239		
3	1,258		
4	1,270		
5	1,221		

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,253
Extreme variation	57
Mean variation	18.6
Mean pressure, pounds per square inch	21,500

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[Charge 66.5 grains Du Pont black powder—45 cal. primer exposed for twenty-four hours over water in a closed vessel.]

Number of shot.	Mean velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,276	20,000	22,500
2	1,272	20,000	21,500
3	1,268	20,000	21,500
4	1,260	20,000	21,000
5	1,277	20,000	22,500

Mean velocity at 53 feet from muzzle	foot seconds..	1,271
Extreme variation	do....	7
Mean variation	do....	5.2
Mean pressure per square inch	pounds..	22,000

Six loaded .45 caliber cartridges, having a charge of 32 grains Walsrode powder and a 405 grain bullet and a primer strengthened with one-fifth grain black powder furnished by Mr. Hesse at the same time as the powder, were fired with the following result:

Number of shot.	Velocity at 53 feet from muzzle.
	Ft. secs.
1	1,366
2	1,391
3	1,311
4	1,318
5	1,377
6	1,341
Mean	1,350
Extreme variation	80
Mean variation	32.8

The powder was tried in the ordinary loading machine for .45 caliber cartridges, but would not discharge properly. In the improved machine for loading .30 caliber cartridges the results were better, but a great many of the powder grains adhered to the hole in charger and discharged also to the funnels of the loading dies. The greatest variation in 25 measured charges was 1.3 grains.

REMARKS.

Primer.—The E 4 primer gives a considerable increase in velocity and seems to give no improvement in uniformity of velocity. With this primer 28.5 grains of powder gives the same velocity as 30.5 grains when the ordinary .45 caliber primer is used. The latter charge fills the case to the seat of the bullet.

Velocity.—The two charges previously mentioned, using the appropriate primer, give the standard velocity required. The uniformity of velocity obtained in the rifle was much inferior to that given by the service charge of black powder.

Pressure.—The pressure recorded with the strongest primer used was not greatly in excess of that of the service charge of black powder.

Effect of heat and moisture.—The results indicate that the Walsrode and black powders are affected very similarly by heat and moisture. The uniformity of velocity of the latter is much superior to that of the former under these tests as also under normal conditions.

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Machine loading.—The Walsrode powder does not seem to be well adapted for machine loading.

Owing to the limited quantity of the sample furnished it was impossible to make a proper accuracy test. For the same reason other standard tests were omitted.

CHARLES H. CLARK,
Captain, Ordnance Department.

J. W. BENÉT,
First Lieutenant, Ordnance Department, Recorder.

The COMMANDING OFFICER, FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 27, 1893.

Respectfully forwarded to the Chief of Ordnance, U. S. Army.

It is a well-recognized fact that variations in pressures with nitro-compounds are not of infrequent occurrence and that these conditions are inexplicable in nature. For this reason I should anticipate that great trouble would result in service by a change from black to smokeless powders for the Springfield rifle. The cam seat is simply calculated to resist the moderate and uniform pressures due to 70 grains of black powder, but if once indented and the breechblock space increased thereby, the cartridge is inadequately supported. This was forcibly illustrated when the Springfield caliber .30 experimental rifle was employed, although of course the defect of the system should be more pronounced in that caliber than in the caliber .45 rifle.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

(6269 B–93)

VII.—RIFLEITE POWDER, .45 CALIBER.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 15, 1893.

SIR: The board on smokeless powders, appointed by Post Orders 23 and 34, series of 1893, respectfully submits the following report of tests of .45 caliber rifleite, made in obedience to first indorsement on letter of L. G. Duff Grant, secretary Smokeless Powder Company, Limited, London, England, to Commanding Officer Frankford Arsenal, dated London, November 18, 1893.

Two packages of cartridges for the .45 caliber Springfield rifle, prepared by the Smokeless Powder Company, were received.

The following results were obtained:

[.45 caliber rifleite cartridges. Charge unknown. Five-hundred grain bullet]

Number of shot.	Velocity at 53 feet from muzzle.
	Ft. secs.
1	1,225
2	1,230
3	1,224
4	1,231
5	1,233
6	1,246
Mean	1,231
Extreme variation	22
Mean variation	5

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[.45 caliber cartridges loaded with service black powder (Du Pont).]

Number of shot.	Velocity at 53 feet from muzzle.
	Ft. secs.
1	1,220
2	1,268
3	1,260
4	1,265
5	1,267
6	1,269
Mean	1,268
Extreme variation	20
Mean variation	3.8

The powder, wads, and primers were removed from five of the cartridges and loaded into cartridge cases prepared for pressures. The weight of charge was found to be 27 grains; three wads were used.

The pressure cartridges were fired in the .45-caliber pressure rifle with the following result:

Number of shot.	Velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,178	20,000	25,500
2	1,210	20,000	24,500
3	1,157	20,000	20,500
4	1,210	20,000	24,500
5	1,207	20,000	24,000

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,192
Extreme variation	53
Mean variation	20
Mean pressure, pounds per square inch	24,000

The service charge of black powder (68.5 grains) fired in the pressure rifle under the same conditions gave:

Number of shot.	Velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,268	20,000	20,500
2	1,232	20,000	21,500
3	1,252	20,000	22,500
4	1,259	20,000	21,500
5	1,278	20,000	22,500

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,258
Extreme variation	46
Mean variation	12.1
Mean pressure pounds per square inch	22,000

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A charge of 72 grains of black powder (0.4-inch compression), the greatest charge that could be loaded into the case without unduly crushing the powder, was fired in the pressure rifle with the following result:

Number of shot.	Velocity at 53 feet from muzzle.	Initial compression of pressure cylinders per square inch.	Pressure indicated per square inch.
	Ft. secs.	*Pounds.*	*Pounds.*
1	1,364	20,000	25,000
2	1,333	20,000	24,500
3	1,333	20,000	25,500
4	1,334	20,000	25,500
5	1,334	20,000	24,500

	Foot seconds.
Mean velocity at 53 feet from muzzle	1,340
Extreme variation	31
Mean variation	10
Mean pressure, pounds per square inch	25,000

The cartridges received gave less velocity than is required in the .45 caliber Springfield rifle. It is probable by increasing the charge that a suitable velocity could be obtained without an excessive pressure. More powder would be required to determine this.

CHARLES H. CLARK,
Captain of Ordnance.

J. W. BENÉT,
First Lieutenant, Ordnance Department, Recorder.

The COMMANDING OFFICER, FRANKFORD ARSENAL.

FRANKFORD ARSENAL,
Philadelphia, Pa., December 26, 1893.

Respectfully forwarded to the Chief of Ordnance U. S. Army.

It appears that a mean velocity of not more than 1,192 foot seconds at 53 feet from the muzzle was realized with the rifleite from the .45 caliber rifle, as against 1,258 foot seconds, with the black powder, whilst the pressures were 10 per cent greater with the former powder than with the latter.

The board states that "It is probable by increasing the charge that a suitable velocity could be obtained without an excessive pressure," but presumably a greater pressure than 24,000 pounds per square inch would result—say at least 26,000 pounds.

The limit specified for the black-powder pressure per square inch in our contracts is 30,000 pounds when employing the Rodman gauge, which is equivalent to 22,000 pounds per square inch with the crusher gauge. The effort, therefore, must be to keep down the pressures to this latter figure, and powders not fulfilling this condition will not be acceptable for our Springfield rifle, an arm not well calculated to resist in its cam seat a pressure due to the employment of 80 grains of black powder when the 500-grain bullet is used.

J. P. FARLEY,
Lieut. Col., Ordnance Department, Commanding.

(187 E–93)

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APPENDIX 10.

EPORT OF TESTS OF SMOKELESS POWDERS FOR SMALL ARMS AND CANNON AT THE CHEMICAL LABORATORY, FRANKFORD ARSENAL, PENNSYLVANIA.

CHEMICAL LABORATORY,
Frankford Arsenal, Pa., August 31, 1894.

SIR: I have the honor to submit the following report for the year ding June 30, 1894, of the principal operations at the chemical labora- ry established at Frankford Arsenal, for the purpose of investigation high explosives and smokeless powders.

Many varieties of smokeless powder have been obtained both of for- gn and domestic manufacture. Some of them have been analyzed d most have been subjected to various tests, to ascertain if they were itable for use in service. Investigations have been made with regard their probable keeping qualities, as indicated by the stability test. nearly every case where the results obtained were not satisfactory, e powders have eventually shown signs of decomposition by the pearance of red fumes of nitrogen-tetroxide.

The time has been too short to determine positively with reference the permanent stability of those powders, which at present appear per- tly stable.

For the purpose of examining and inspecting powders, especially ose delivered under contract, a series of tests have been deter- ned on.

As some method of obtaining low temperatures was desired, an paratus was constructed from a magazine sketch of "Cailetet's yogen." This at first did not prove very satisfactory, but after sev- al modifications worked much better; the required temperature was ore easily obtained and held, and the amount of liquefied carbon oxide used was greatly reduced. At present about 5 pounds are quired to maintain a temperature of —40° F. for six hours. The greater rtion of this is used to reduce the cooling chamber to the proper tem- erature. Comparatively little more is needed to hold the same during e test.

A short trial was made to ascertain the effect of sunlight on a few of e two general classes of smokeless powders, i. e., those containing troglycerin and those in which this substance does not enter.

The results of flashing representatives of these two classes of pow- ers on polished steel plates, and allowing the residue to remain for rying lengths of time, has been investigated to a slight extent.

Other examinations for the purpose of ascertaining the various quali- es of smokeless powders have been commenced, but have not suffi- ently progressed to be of any value.

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The following samples of high explosives and smokeless powders have been received:

HIGH EXPLOSIVES.

Walsrode gun cotton.
Tschirner.
Emmensite.

SMOKELESS POWDERS FOR CANNON.

German (cubical), 8-inch rifle.
Leonard, N., $\frac{1}{2}$, United States.
Troisdorf, II, Germany.
Cordite (Armstrong's R. F. gun).
B. N. 12-inch rifle (French).
Leonard, N., $\frac{3}{4}$, United States.
Troisdorf, III, Germany.

SMOKELESS POWDERS FOR SMALL ARMS.

Wetteren, Belgium.
New Wetteren, Belgium.
Cannonite, England.
Rifleite, caliber .30, England.
New rifleite, caliber .45, England.
S. R., caliber .45, England.
S. V., revolver, England.
B. N. F., France.
Troisdorf, I, Germany.
New Troisdorf (VI), Germany.
Walsrode, caliber .45, Germany.
New Walsrode, caliber .30, Germany.
Swiss, Switzerland.
Axtell, Nos. 1, 2, 3, United States.
DuPont, United States.
Horés, United States.
Leonard, J., United States.
Leonard, N., United States.
Leonard, J. (fine), United States.
Leonard, N. (small), United States.
Peyton, United States.
Peyton, glazed, United States.
Peyton, unglazed, United States.
Waltereck, United States.
Weidig, United States.

In order to examine more uniformly the powders received under contract, certain laboratory tests were determined upon, viz: Exposure to heat 130° F., cold —40° F., air saturated with moisture. To the same, and afterwards exposed to the air; air exposure and stability. The specific gravity, gravimetric density, granulation, residue from flashing, temperature of ignition are determined, and lately the heating effect on the barrel.

In applying these tests the following general method is employed:—

A sample of the powder (about 65 grams), placed in a tared glass-stoppered weighing bottle, is carefully weighed, transferred to the proper vessel, exposed to the test, returned to the weighing bottle, and when the latter has attained the atmospheric temperature, the whole is reweighed. The change of weight is calculated in percentages of the original weight of sample. The powder remains in closed vessels until loaded by hand in the cartridge cases.

When loaded cartridges are subjected (10 for velocity and 5 for pressure) to heat or cold, at the conclusion of the exposure they are transferred to a closed felt-lined vessel, taken to the proof house and placed as soon as possible in the chamber of the rifle by means of a pair of wooden tongs.

When the test cartridges are loaded, a duplicate set is prepared for firing at the same time to establish a standard.

Heat test.—The sample in an open metallic box about $3\frac{3}{4}$ inches in diameter, 2 inches deep, and provided with a bottom of fine wire gauze, is placed in a water-jacketed drying oven, where it is exposed for twenty-four hours to a temperature of 130° F.

Fifteen cartridges are treated in a similar manner, except that the change of weight is not noted.

Cold test.—The object of this test is to ascertain whether exposure to low temperature (not to exceed —40° F.) has any permanent effect on the powder, and, in the case of loaded cartridges, the ballistic results from firing while the powder has as nearly as possible the above temperature. The times of exposure are four periods of six hours each. The

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powders are placed in closed metallic boxes. Fifteen loaded cartridges are exposed for the same length of time.

The apparatus used is a "Cailletet's Cryogen" in a somewhat modified form. The available space is cylindrical, 4 inches in diameter and 6½ inches high.

The reduction of temperature is obtained by means of liquefied carbon dioxide. A temperature of −70° F. has been obtained.

Moisture test.—The sample in boxes, similar to those used in the heat test (4½ inches diameter, 1½ inches deep), is placed in a closed double box on a false bottom of wire gauze, beneath which is a shallow pan containing water. A maximum and minimum thermometer is hung near the sample. Time of exposure, twenty-four hours. Fifteen cartridges are exposed in like manner for one week.

Moisture and air exposure.—Another sample, after having been treated as above and weighed, is spread out on a glass plate and covered in such a manner as to allow free circulation of the air and to protect it from dust. Times of exposure to moisture and air, twenty-four hours each. During the latter portion of the test several readings of the wet and dry bulb thermometers are taken.

Air exposure.—Same as the latter portion of the preceding test.

Stability test.—About one gram of the powder is exposed to a temperature of 65.5° C. (150° F.) in a closed test tube containing a piece of potassium iodide starch paper. At least fifteen minutes should elapse before the slightest trace of discoloration of the paper appears.

The formula for the paper used is that mentioned in Lieut. Walke's "Lectures on explosives," viz: Dry white starch, 45 grains; water, 8½ ounces; potassium iodide, 15 grains; water, 8½ ounces.

Flash or residue.—One gram of the powder is flashed by means of a burning glass on a weighed glass plate (2 by 2 inches) placed on a clean sheet of glazed paper, in order to collect the flocculent residue; this latter is returned to the glass, which, when sufficiently cool, is reweighed and the increase calculated to percentage of the powder taken.

Temperature of ignition.—The object of this test is to ascertain the length of time and the temperature required to ignite or explode a single grain of the powder when placed in contact with a copper surface heated to a known temperature (about 150° C. to 275°) (302° to 527° F.).

The apparatus consists of two similar copper vessels terminating in a very thin copper tube closed at the lower end and floating in a paraffine bath. Into one tube is dropped the grain of powder, while in the other is placed the bulb of a thermometer so as to just touch the bottom. The temperature is noted, and the length of time elapsing before explosion is taken by means of a stop watch.

Specific gravity.—Is taken by means of a mercury densimeter, 200 grains being used for smokeless and 3,000 grains for black powder. The density is determined from the formula

$$D=\frac{a\ d}{P-P'+a}$$

D=density of powder.
P=weight of bulb filled with mercury.
P′=weight of bulb with mercury and powder.
a=weight of powder taken.
d=density of mercury corrected for temperature.

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Gravimetric density.—Is determined by means of a Dupont gravimeter, by means of which the weight of a cubic foot of powder in ounces is read directly from the beam.

The vase has a capacity of 5,000 grains of water, or 0.01143 cubic feet. If water is taken as 1,000 the gravimetric density will be expressed in whole numbers; if as 1, then as a decimal fraction.

Sieve test.—Six sieves are so arranged vertically as to leave between their meshes about 1 inch space, with the size of hole decreasing downward. The holes are circular, having about the following diameters: 0.10, 0.09, 0.08, 0.07, 0.06, and 0.03 inch.

Twenty-five grams of powder are placed on the upper sieve and the whole system given a horizontal motion. All powders remaining on or in a particular sieve, are designated + the size of mesh; all passing through the lower sieve as, —0.03, or dust, as the case may be.

The weights of these portions are calculated to percentages of the original weight of powder taken.

Heating of barrel.—The temperature of the barrel of the rifle is taken by means of a thermometer placed in the bore. Twenty-five rounds are fired in about one minute. (The case from the last round is retained in the chamber.) A maximum thermometer is lowered into the bore so that the bulb is about opposite the position occupied by the bullet in the loaded cartridge. The muzzle is closed by means of a cork through which passes the wire supporting the thermometer; after a few minutes the latter is removed and temperature noted, as is also the time required to fire the 25 rounds.

The following powders have been more particularly examined

GERMAN SMOKELESS POWDER.

The sample was received from Sandy Hook Proving Ground (September 16, 1893), where it is used in the 8-inch B. L. rifle.

The surface of the grains appear to have been covered with graphite. Two of the opposite surfaces are smooth, two others diagonally striated, and on the remaining two the striæ are in some cases parallel to the edge, but generally diagonal.

The color of the cross section is dark, but in thin sections it is translucent and of a horn-like appearance, showing a definite line at about the middle of the grain and parallel to the smooth surfaces.

On bending a thin section along this line a clean break is obtained, which is not the case when bent at right angles to this line. This would indicate that the grain was formed finally from two sheets.

The composition is soft enough to be indented by the finger nail and has a specific gravity of 1.628.

Granulation about 279 pieces per pound. The average weight (40 pieces) per piece was 1.027 grains, and the form very nearly that of a cube, as the dimensions were 0.398 by 0.388 by 0.400 inch.

A residue of $1\frac{72}{100}$ per cent remained after flashing on a glass plate.

The following changes of weight were noted after submitting the powder to the following tests:

To a temperature of 130° F. for twenty-four hours, lost 0.7577 per cent.

To a saturated atmosphere for twenty-four hours, gained 0.2577 per cent.

To a temperature of —40° F. for twenty-four hours, lost 0.1675 per cent.

(Four periods of six hours each.)

In none of the above tests was any indication of the exudation of nitroglycerin noted.

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TROISDORF I.

On September 24, 1892, about 112 pounds of this powder was received om the Rhenische-Westphalische-Sprengstoffgesellschaft, Cologne n the Rhine, for use in the .30-caliber rifle.

The surface of the grains is covered with graphite, and the cross ection is of a light color. The composition is too hard to be indented ith the finger nail.

The grains are essentially in the form of square plates, having an verage surface of .06 by .06 inch, and a thickness about .013 inch. he edges are somewhat ragged and turned up on one side. Some of he grains are rectangular, measuring .111 by .058 inch.

The following percentage of various sized grains was obtained by ifting:

+ 08 — 0.022 per cent, + 07 — 0.858, + 06 — 61.82 per cent, + 03 -37.30 per cent.

The average granulation is 460,925 pieces per pound.

Specific gravity, 1.552.

Gravimetric density, 680.

A residue of 10½ per cent remained after flashing the powder on a lass plate.

With the U. S. magazine rifle, caliber .30, a charge of 35 grains and 220-grain German-silver jacketed bullet, a mean velocity of 1,971 foot econds was obtained, with a maximum variation of 48 foot seconds nd a mean variation of 15.76 foot seconds.

The pressure obtained with a similar charge was 40,325 pounds per quare inch; the copper having had an initial compression of 32,900 ounds per square inch, a strong primer was necessary to insure ignition.

Heating the powder to a temperature of 130° F. for twenty-four hours aused a loss of 1.292 per cent in weight. Exposure to an atmosphere aturated with moisture for twenty-four hours caused the powder to osorb 1.64 per cent of its original weight.

The powder is stable according to the test as the iodide of potas-ium—starch paper was not discolored after an exposure of more than n hour.

NEW WETTEREN.

On October 18, 1893, 500 pounds of this powder was received from öopal & Cie., Belgium, through Messrs. Du Pont & Co., for use in the 0-caliber rifle.

The color of the grains varies from a light gray to brown, the surface aving a slightly glazed appearance.

When first exposed to the air a distinct odor is noticeable.

The general form of grain is that of a square plate with the edges ore or less roughened as if cut with a dull instrument. The dimen-ons are about .06 by .08 inch, having a thickness of from .014 to .018 ch. A few grains are twice or three times the average length, having arks where the grains should have been separated.

The following percentage of the various sized grains was obtained by ifting:

+ 10 — 0.048 per cent, + 09 — 0.098 per cent, + 08 — 1.063 per cent, 07 — 39.122 per cent, + 06 — 51.558 per cent, + 03 — 8.091 — 03 — 0.020 er cent—slight amount of dust.

The average granulation was 339,329 pieces per pound.

Specific gravity, 1.5075.

Gravimetric density, 706.5.

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A residue of 5 per cent was left after flashing on a glass plate. With the Springfield experimental rifle, caliber .30, a 220-grain German-silver jacketed bullet and a charge of 35 grains, a velocity (53) of 1,917 foot seconds was obtained and a pressure of 49,000 pounds per square inch.

The powder subjected to the heat test (130° F.) lost 0.849 per cent in weight, gained 46 feet in velocity (53), and some 3,500 pounds per square inch in pressure. A gain of 55 feet in velocity (53) was obtained when cartridges having a temperature of 130° F. were fired.

Exposed to moisture the powder gained 1.444 per cent in weight, lost 53 feet in velocity and 1,500 pounds per square inch in pressure. Exposed to moisture and dried in the air lost 0.322 per cent, a slight gain in velocity; pressure not changed. Exposed to cold (—40° F.) lost 0.0244 per cent in weight, 35 feet in velocity, and 1,500 pounds per square inch in pressure. Fired at a temperature of nearly —40° F. the loss in velocity (53) was 79 feet.

The powder was heated for more than an hour without affecting the iodide of potassium-starch paper.

LEONARD, N, $\frac{7}{16}$.

This powder was received July, 1893, from Sandy Hook, where it had been used in the 3.2-inch rifle.

With a projectile weighing 13½ pounds, and a charge of 2 pounds 3½ ounces, 2,257 feet velocity, and a pressure of 36,500 pounds per square inch were obtained.

The grains are of a dark lemon color, have a strong oily odor, and are tubular in shape.

The lengths range from 0.508 to 0.560 inch, and the diameters from 0.321 to 0.585 inch. Diameter of hole about 0.14 inch. Many of the cylinders are flattened owing to the soft oily composition of the powder.

Weight of a single piece 1.23 grams (average of 30). Specific gravity, 1.630. Granulation, about 368 pieces per pound.

A residue of 3½ per cent remained after flashing.

On exposure to a temperature of 130° F. for twenty-four hours caused a loss of 0.346 per cent, with very slight oily exudation.

PEYTON POWDER.

This powder was received from the California Powder Company, under contract, dated December 18, 1893, and was delivered at this arsenal in lots, as follows:

Lot.	Pounds.	Date.	Lot.	Pounds.	Date.
		1894.			1894.
1	100	Apr. 9	7	600	May 29
2	100	Apr. 11	8	600	May 29
3	200	Apr. 23	9	600	June 20
4	500	May 8	10	600	June 20
5	500	May 8	11	500	June 20
6	700	May 8			

The powder was received in boxes lined with sheet metal and provided with a rubber gasket between the box and cover. The contents of each box, 100 pounds.

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Each lot as received was tested; duplicate tests for stability were ade from each package. When the lot consisted of more than one ckage, equal quantities of the powder were taken from each, thoroughly ixed, and this was subjected to the other chemical, physical, and llistic tests.

The general form of the grain is that of an irregular hexagonal prism easuring about 0.058 inch across and 0.250 inch long. A few of the ains have a length of 0.400 inch and are rather wedge-shaped at e ends; others are formed of two or more grains joined laterally (not aving been separated when formed). These double grains, although ite frequent at first, became less so in subsequent lots.

The surface of the grain is graphited and has a polished appearance, lges somewhat rounded (as if the grains had been tumbled), and though seemingly quite hard can be compressed by the finger nail. he powder has an odor greatly resembling that of methyl alcohol.

The following table giving the maximum and minimum percentage of e various sized grains (together with the number of the lot in which occurred) was obtained by sifting 25 grams from each lot:

	+".10	+".09	+".08	+".07	+".06	+".03	—".03
Maximum ..	0.252 (5)	4.241 (4)	17.783 (3)	89.719 (11)	11.284 (6)	0.801 (4)	None.
Minimum...	0.023 (1)	3.600 (8)	2.140 (10)	53.509 (6)	5.990 (3)	None.	None.

No dust.

The granulation of +.07 grain (86,589 per cent of lot 9) is 87,545 eces per pound. The granulation of +.07 grains (86.068 per cent of t 10) is 87,857 pieces per pound.

The specific gravity of the powder varies from 1.669 in lot No. 1 to 348 in lot No. 5.

The gravimetric density varies from 1,049 (lot No. 1) to 976 (lot No. 11).

The residue remaining after flashing was from 2½ per cent (lot 1) to per cent (lot 4).

Stability.—The first faint trace of discoloration of the iodide of potas- um starch paper in the stability test occurred in lot No. 1 after 1½ urs, in lot No. 3 after 34 minutes. These results were averages of o or more tests.

Lot No. 2 was rejected as unstable, as the time of exposure, before scoloration (18 tests), varied from 5½ to 14 minutes. The general sts were, however, made with this lot, the results of which are sepa- tely shown in the subsequent table.

Single grains of Peyton powder (lot 1) were heated to various tem- ratures and effect noted. At 285° to 289° F. the substance boiled, but d not explode. At about 293° F. it exploded after 58 seconds; at 8° F. after 24 seconds; at 365° F. after 17 seconds; at 392° F. after 14 conds. All the grains boiled up a few seconds before exploding.

The velocities at 53 feet, obtained with the United States magazine le, caliber .30, a 220-grain German silver jacketed bullet and a charge 44 grains (lots 1–6) varied from 2,135 feet (lot 5) to 1,982 feet (lot 1). ith a charge of 43 grains (lots 7–11) from 2,083.9 (lot 9) to 1,986.7 (lot 8). With the above charges the pressures obtained in lots 1–6 were 41,216 unds per square inch (lot 5) to 30,900 (lot 1); in lots 7–11, 34,670 (lot to 31,163 (lot 7).

Heating of barrel.—Firing 25 rounds of Peyton powder (lot 3) 44 grains arge in 64½ seconds, increased the temperature of the bore (just in nt of the chamber) from 89° F. to 196° or 107° F.

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Results of special tests of Peyton powder (divided into two groups on account of change in charge) showing maximum and minimum per cent change of weight and effect on velocity and pressure.

[Lots 1-6. Charge, 44 grains.]

Test.	Change of weight.		Change in velocity.		Change in pressure.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
	Per cent.	*Per cent.*	*Feet.*	*Feet.*	*Pounds.*	*Pounds.*
Heat	—0.67 (6)	—0.176 (1)	+66.18 (4)	+7.20 (1)	+3,806 (4)	+888 (1)
Cold	+0.505 (1)	+0.131 (6)	—39.2 (3)	—17.1 (5)	—1,665 (1)	—670 (5)
Moisture	+1.200 (4)	+1.085 (6)	—142.4 (3)	—109.67 (4)	—5,976 (5)	—3,390 (1)
Air	+0.168 (1)	+0.004 (5)	+42.8 (5)	—11.8 (3)	—2,169 (6)	—140 (1)
Moisture and air	+0.190 (1)	+0.006 (3)	—35.98 (6)	—16.0 (3)	—2,508 (1)	—535 (5)
Heat	.....	.....	+111.87 (6)	+66.5 (5)	+8,481 (6)	+2,330 (1)
Cold	.....	.....	—99.8 (5)	—69.19 (1)	—3,086 (5)	—1,147 (6)
Moisture	.....	.....	+14.6 (1)	+3.57 (5)	—1,112 (5)	+149 (6)

[Lots 7-11. Charge, 43 grains.]

Test.	Change of weight.		Change in velocity.		Change in pressure.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
	Per cent.	*Per cent.*	*Feet.*	*Feet.*	*Pounds.*	*Pounds.*
Heat	—0.525 (8)	—0.380 (9)	+67.3 (7)	+10.7 (9)	—2,080 (11)	+930 (10)
Cold	+1.0822 (8)	+0.790 (10)	—99.3 (8)	—60.9 (10)	—2,850 (9)	—730 (8)
Moisture	+1.756 (11)	+1.235 (7)	—207.4 (11)	—134.9 (7)	—3,230 (9)	—130 (10)
Air	+0.399 (11)	+0.068 (7)	—63.6 (9)	—1.8 (8)	—3,000 (9)	—30 (10)
Moisture and air	+0.428 (11)	+0.129 (8)	—65.9 (10)	—30.1 (8)	—2,650 (9)	+260 (10)
Heat	.....	.....	+86.55 (9)	+56. (10)	+11,260(10)	+3,665 (7)
Cold	.....	.....	—150.8 (8)	—110.5 (9)	—1,780 (8)	—380 (11)
Moisture	.....	.....	—17.2 (8)	—3.3 (7)	—3,031 (8)	—140 (10)

Each velocity and pressure is the average of 10 shots, except in the case of loaded cartridges, where only 5 pressures were taken.

The figures in parentheses indicate the number of the lot of powder.

General summary of Peyton powder.

[Charge, 44 grains. Bullet, German silver, 220 grains weight.]

[Specific gravity, 1.669; gravimetric density, 1,049; residue, 2.5 per cent.]

Nature of test.	Change in weight.	Velocity standard (mean).	Change from standard (mean).	Pressure standard (mean).	Change, pressure from standard (mean).	Granulation.	
						Diameter sieve.	Per cent.
Peyton 1.	*Per cent.*		*Ft. secs.*		*Pounds.*	*Inches.*	
Heat	—0.1758	1,982.8	+7.2	30,900	+888	+.10	0.0232
Cold	+0.5054	2,011.85	—36.15	33,114	—1,665	+.09	0.3880
Moisture	+1.1966	1,982.8	—133.8	33,933	—3,390	+.08	10.0152
Air dried	+0.1680	1,992.6	—27.0	32,140	—140	+.07	66.3076
Moisture and air dried	+0.1904	1,983.0	—17.3	33,933	—2,508	+.06	23.2560
Heat cartridges	.....	1,989.6	+106.8	32,730	+2,330	+.03	0.0100
Cold cartridges	.....	2,012.8	—69.19	34,090	—2,724	—.03	0.0000
Moisture cartridges	.....	2,009.4	+14.60	33,590	+470	Dust.	None.

[Specific gravity, 1.659; gravimetric density, 1,002; residue, 3 per cent.]

Peyton 2.							
Heat	—1.0324	2,033.2	+101.46	33,428	+8,329	+.10	0.1712
Cold	—0.0672	2,048.4	—3.60	36,454	+1,020	+.09	2.3704
Moisture	+0.4792	2,033.2	—44.80	33,428	+749	+.08	13.8908
Air dried	—0.5777	2,033.2	+80.80	33,428	+5,197	+.07	75.6716
Moisture and air dried	—0.6068	2.033.2	+67.30	33,428	+6,369	+.06	7.8960
Heat cartridges	.....	2.035.4	+118.60	34,160	+9,020	+.03	0.0000
Cold cartridges	.....	2,045.33	—118.53	36,768	—2,850	—.03	0.0000
Moisture cartridges	.....	2,049.47	—16.72	35,218	+548	Dust.	None.

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General summary of Peyton powder—Continued.

[Charge, 44 grains. Bullet, German silver, 220 grains weight.]

[Specific gravity, 1.666; gravimetric density, 1,008; residue, 2.5 per cent.]

Nature of test.	Change in weight.	Velocity standard (mean).	Change from standard (mean).	Pressure standard (mean).	Change, pressure from standard (mean).	Granulation.	
						Diameter sieve.	Per cent.
Peyton 3.	*Per cent.*		*Ft. secs.*		*Pounds.*	*Inches.*	
at	—0.4230	2,016.6	+29.15	34,705	+1,209	+.10	0.1708
d	+0.4463	2,025.9	—39.20	34,802	—1,262.5	+.09	3.9748
isture	+1.0930	2,016.6	—142.4	34,967	—4,346	+.08	17.7828
dried	—0.0293	2,016.6	—11.80	34,705	+262	+.07	72.0820
isture and air dried	+0.0069	2,016.6	—16.00	34,967	—1,118	+.06	5.9896
t cartridges		2,010.4	+101.80	35,675	+4,735	+.03	0.0000
l cartridges		2,027	—75.00	34,222	—2,609.5	—.03	0.0000
isture cartridges		2,034.15	—11.65	34,058	—1,002	Dust.	None.

[Specific gravity, 1.656; gravimetric density, 999; residue, 1 per cent.]

Peyton 4.							
t	—0.5499	2,087.07	+66.18	37,183	+3,806	+.10	0.1680
l	+0.1425	2,087.07	+28.81	37,183.5	+1,104	+.09	4.2412
isture	+1.2005	2,087.07	—109.67	37,183	—5,958	+.08	12.1768
dried	—0.0422	2,067.6	+16.40	36,831	+874	+.07	55.3048
isture and air dried	+0.1716	2,130.4	—29.50	40,465	—1,043	+.06	27.3080
t cartridges		2,115.58	+72.67	38,820	+7,967	+.03	0.8012
l cartridges		2,059.5	—96.50	37,941	—2,793	—.03	0.0000
isture cartridges		2,092.9	+13.01	38,275	—720	Dust.	None.

[Specific gravity, 1.649; gravimetric density, 1,000; residue, 1.5 per cent.]

Peyton 5.							
t	—0.5731	2,098.4	+36.6	37,666	+3,521	+.10	0.2520
	+0.1328	2,098.4	—17.1	37,666	—670	+.09	3.8240
ture	+1.1923	2,098.4	—116.2	37,666	—5,976	+.08	11.1240
dried	+0.0044	2,061.7	+42.8	37,338	—722	+.07	53.7224
ture and air dried	+0.1548	2,135.3	—19.8	41,216	—835	+.06	31.0340
cartridges		2,115.17	+66.50	38,910	+4,330	+.03	0.0436
cartridges		2,082.4	—99.8	37,010	—3,086	—.03	0.0000
ture cartridges		2,116.88	—10.12	39,048	—1,112	Dust.	None.

[Specific gravity, 1.654; gravimetric density, 1,014; residue, 1 per cent.]

Peyton 6.							
t	—0.6701	2,076.68	+33.89	35,227.5	+1,578.5	+.10	0.0840
	+0.1314	2,045.68	—19.93	33,398	—974.0	+.09	0.6160
ture	+1.0854	2,076.68	—141.01	35,227.5	—4,018.5	+.08	4.4200
dried	+0.0394	2,076.68	—17.90	35,227.5	—2,169.5	+.07	53.5084
ture and air dried	+0.0777	2,076.68	—35.98	35,227.5	—2,027.5	+.06	41.2836
cartridges		2,060.13	+111.87	33,576	+8,481.5	+.03	0.0880
cartridges		1,996.7	—85.06	32,360	—1,147	—.03	0.0000
ture cartridges		2,058.08	+3.57	33,608	+149	Dust.	None.

[Specific gravity, 1.661; gravimetric density, 1,020; residue, 1.5 per cent, charge, 43 grains.]

Peyton 7.							
t	—0.4899	1,988	+67.3	31,163	+1,472	+.10	0.1500
	+0.9543	1,994.6	—88.65	32,180	—870	+.09	0.6824
ture	+1.2359	1,988	—134.90	31,163	—469	+.08	4.5880
dried	+0.0980	1,988.6	—5.0	30,930	+458	+.07	84.9404
ture and air dried	+0.1506	1,988	—36.8	31,163	+275	+.06	9.6220
cartridges		2,003.6	+86.5	28,695	+3,665	+.03	0.0172
cartridges		1,996.6	—150.3	29,210	—1,380	—.03	0.0000
ture cartridges		2,000.4	—3.3	33,213	—1,506	Dust.	None.

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General summary of Peyton powder—Continued.

[Charge, 44 grains. Bullet, German silver, 220 grains weight.]

[Specific gravity, 1.657; gravimetric density, 1,017; residue, 1.5 per cent.]

Nature of test.	Change, in weight.	Velocity standard (mean).	Change from standard (mean).	Pressure standard (mean).	Change, pressure from standard (mean).	Granulation.	
						Diameter sieve.	Per cent.
Peyton 8.	*Per cent.*		*Ft. secs.*		*Pounds.*	*Inches.*	
Heat	—0.5254	1,997.8	+29.0	33,144	+1,679	+.10	0.1168
Cold	+1.0822	2,009.2	—99.35	32,690	—780	+.09	0.3800
Moisture	+1.2988	1,997.8	—170.0	33,144	—1,898	+.08	4.0024
Air dried	+0.1512	1,986.7	—1.8	31,626	—767	+.07	88.1740
Moisture and air dried	+0.1297	1,997.8	—30.1	33,144	—1,039	+.06	7.2748
Heat cartridges	.....	1,999	+61.3	29,131	+5,805	+.03	0.0780
Cold cartridges	.....	2,003.4	—150.85	33,560	—1,780	—.03	0.0000
Moisture cartridges	.....	1,993.8	—17.2	34,767	—3,031	Dust.	None.

[Specific gravity, 1.656; gravimetric density, 982; residue, 1.68 per cent.]

Peyton 9.							
Heat	—0.3802	2,083.94	+10.68	34,670	—1,590	+.10	0.0906
Cold	+1.0205	2,083.94	—81.54	34,670	—2,850	+.09	0.6680
Moisture	+1.5413	2,083.94	—188.07	34,670	—3,230	+.08	2.9144
Air dried	+0.3631	2,083.94	—63.64	34,670	—3,000	+.07	86.5688
Moisture and air dried	+0.3859	2,083.94	—54.44	34,670	—2,650	+.06	9.7224
Heat cartridges	.....	2,070.4	+86.55	35,360	+8,500	+.03	0.0156
Cold cartridges	.....	2,074.75	—110.55	33,040	—1,340	—.03	0.0000
Moisture cartridges	.....	2,074.75	—14.53	33,040	+2,720	Dust.	None.

[Specific gravity, 1.658; gravimetric density, 979; residue, 1.48 per cent.]

Peyton 10.							
Heat	—0.4058	2,073.65	+25.67	31,450	+930	+.10	0.0784
Cold	+0.7900	2,033.1	—60.90	32,880	—1,120	+.09	0.6896
Moisture	+1.5566	2,073.65	—171.07	31,450	—130	+.08	2.1400
Air dried	+0.2340	2,073.65	—31.95	31,450	—30	+.07	88.0676
Moisture and air dried	+0.3498	2,073.65	—65.95	31,450	+260	+.06	8.9624
Heat cartridges	.....	2,084.1	+56.00	32,380	+11,260	+.03	0.0620
Cold cartridges	.....	2,062.68	—118.70	32,680	—1,420	—.03	0.0000
Moisture cartridges	.....	2,062.68	—7.43	32,680	—140	Dust.	None.

[Specific gravity, 1.654; gravimetric density, 976; residue, 1.56 per cent.]

Peyton 11.							
Heat	—0.3848	2,060.48	+44.72	33,370	—2,080	+.10	0.2240
Cold	+0.8445	2,060.48	—77.78	33,370	—1,130	+.09	1.0184
Moisture	+1.7565	2,060.48	—207.41	33,370	—1,780	+.08	2.9680
Air dried	+0.3997	2,060.48	—32.80	33,370	—590	+.07	89.7188
Moisture and air dried	+0.4283	2,060.48	—46.98	33,370	—860	+.06	6.0480
Heat cartridges	.....	2,082.9	+61.50	32,360	+9,980	+.03	0.0228
Cold cartridges	.....	2,058.15	—116.27	32,040	—380	—.03	0.0000
Moisture cartridges	.....	2,058.15	+5.43	32,040	+400	Dust.	None.

SUN EXPOSURE.

About 13 grams of the following powders, viz, Leonard, N, small; Leonard, J, fine; Peyton, glazed; Peyton, unglazed; rifleite; Walsrode (old); new Troisdorf, new Wetteren, were exposed night and day to the action of the sun, etc., from December, 1893, to February, 1894 (fifty-six days).

They were placed in shallow trays, provided with glass bottoms and protected from the weather by means of a sheet of glass. Temperature readings were taken twice a day, from a maximum and minimum

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thermometer; the highest temperature reached was above 140° F., the lowest was 3° F.

The powders were removed, examined, and weighed from time to time. At the conclusion of the test they were examined for change of weight, velocity, stability, and temperature of ignition, as compared with samples of unexposed powders, with the following results:

Leonard, N, small.—Lost 5.7 per cent in weight. The grains had almost entirely lost their original color, were softer and greasy with a slight tendency to agglomerate, exuded an oily substance which adhered to the glass, edges of grains became slightly rounded. Under the microscope that portion on the glass (0.0357 gram) had the appearance of bubbles. Dissolved off with alcohol and tested for nitroglycerin, could not detect its presence.

Velocity changed from 1,864 to 1,833. Stability greatly reduced. Faint traces in one and one-half minutes (standard six minutes). Temperature of ignition increased.

Leonard, J, fine. Lost 5.48 per cent in weight. Grains changed to a dark, rich claret color with whitish efflorescence (which under the microscope appeared as white, needle-like crystals), had become oily with great tendency to agglomerate and adhere to glass. Exudation on glass (0.0254 gram) formed a heavy adherent film (like ground glass); this dissolved in alcohol, but did not give the test for nitroglycerin.

Velocity about the same. Stability decreased but not sufficiently to be considered unstable. Temperature of ignition slightly lowered.

Peyton glazed.—Lost 2.67 per cent in weight. Grains lost luster and had a dull appearance with a greenish-yellow efflorescence on surface, yellow resinous protuberances exuding from some grains, slight agglomeration; whitish exudation on glass (minute needle-like crystals), which gave a yellowish solution in alcohol.

Velocity reduced. Temperature of ignition increased. Stability slightly decreased.

Peyton unglazed.—Lost 2.134 per cent in weight. General darkening of grains, some covered with a greenish-yellow efflorescence; slight tendency to agglomerate. White film on glass (outlining form of grains), which when dissolved in alcohol and evaporated to dryness left a yellowish residue and minute needle-like crystals.

Velocity reduced from 1,901 to 1,880.5. Stability not affected. Temperature of ignition slightly lowered.

Rifleite.—Lost in weight 1.034 per cent up to 29 days, then gained 0.394 per cent; total loss 0.640 per cent.

Slight tendency to agglomerate; some grains changed color to reddish brown; more polished in appearance; no exudation.

Velocity somewhat reduced. Stability not affected. Temperature slightly lowered.

Walsrode (old).—Lost 0.614 per cent up to 29 days, then gained 0.218 per cent; total loss 0.396 per cent.

General tendency to darken; lighter on edges; very slight efflorescence.

Velocity increased from 1,317.9 to 1,345.9. Very slight change in stability or temperature of ignition.

New Troisdorf.—Lost 1.368 per cent up to 29 days, then gained 1.066 per cent; total loss 0.302 per cent.

No apparent change, except possibly the grains had a less polished appearance.

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Velocity and stability not affected. Temperature of ignition slightly reduced.

New Wetteren.—Lost 0.996 per cent up to 29 days, then gained 0.584 per cent; total loss 0.412 per cent.

Grains slightly darkened. Velocity increased from 1,961 to 1,988. Stability only slightly affected. Temperature of ignition slightly raised.

CORROSION TEST (ON POLISHED STEEL PLATES).

In order to ascertain the comparative effect on steel of the flashing and residues of smokeless powders, containing nitro-glycerin and those which do not contain this compound, powders were flashed on polished Reel plates (2″ by 2″) by means of a burning glass.

Peyton, Leonard, and Leonard N, 7/16 were selected as representatives of the first-class and New Wetteren, New Troisdorf, and New stifleite as those of the second-class.

The residues were allowed to remain on the plates for fifteen minutes, twenty-four hours, and twenty-eight days, respectively, then washed with water, soap and water, and finally with alcohol; dried, weighed, and examined.

Plates 13^1–18^1 show the effect of first, 7^1–12^1 of the second, and 1^1–6^1 of the third test:

Powder.	First test, residue on plate 15 minutes.				Second test, residue on plate 24 hours.				Third test, residue on plate 28 days.			
	Powder flashed.	No.	Residue.	Loss of plate.	Powder flashed.	No.	Residue.	Loss of plate.	Powder flashed.	No.	Residue.	Loss of plate.
	Grams.		*P. ct.*	*Grams.*	*Grams.*		*P. ct.*	*Grams.*	*Grams.*		*P. ct.*	*Grams.*
Peyton	1.0006	13^1	2.9	0.0017	1.0007	7^1	3.01	0.0009	1.0010	1^1	3.42	0.0015
Leonard	1.0009	14^1	5.69	0.0005	1.0006	8^1	5.50	0.0006	1.0002	2^1	6.20	0.0001
Leonard N. 7/16	1.0019	15^1	5.52	0.0008	1.0000	9^1	8.70	0.0009	1.0009	3^1	5.40	0.0012
New Wetteren	1.0006	16^1	5.13	0.0018	1.0002	10^1	5.92	0.0016	1.0012	4^1	5.62	0.0053
New Troisdorf	1.0006	17^1	5.40	0.0019	1.0008	11^1	6.18	0.0018	1.0001	5^1	5.76	0.0011
New Rifleite	1.0000	18^1	3.92	0.0015	1.0000	12^1	4.22	0.0016	1.0000	6^1	4.82	0.0025

The residues of one flashing of each powder are shown on plates 7, 8, 9, 10, 11, 12.

Peyton, plates (13^1, 7, 7^1, 1^1). The residue was formed of black lumps about the size of grain which adhered to plate; these were surrounded by a resinous coating and greyish flocculent flakes.

13^1. After washing. Surface appeared as if burnt in spots of the same shape as the grain.

7^1. About the same as the preceding except the marking was not so dark.

1^1. Very dark resinous appearance in spots; etching perceptible to touch.

Leonard, plates (14^1, 8, 8^1, 2^1). Dark flocculent matter of the shape of grain; white fused globules interspersed among the mass with a background of pearly gray film.

14^1. No change of surface perceptible to touch; dark spots on surface having form of grain.

8^1. Spots darker; small black specks noticeable.

2^1. Spots of a reddish brown color having a definite shape; numerous small dark specks; surface apparently raised when action had taken place.

Leonard, N 7/16, plates (15^1, 9, 9^1, 3^1). Residue dark where grains were in contact surrounded by raised edges. The intermediate space

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covered with slight yellowish brown substance containing numerous white fuzed globules and the whole surrounded by a pearl-gray film.

15¹. Form of grain very well defined on plate by sharp lines surrounded by an iridescent film containing dark spots.

9¹. Marking more definite and darker.

3¹. Outlines not so sharply defined; lighter in color, but apparently deeper; black spots more definite; action on surface not noticeable to the touch.

New Wetteren, plates 16¹, 10, 10¹, 4¹. Form of grains outlined in black flocculent substance; interior space filled with network of a grayish color; resinous film; part of the residue had a fused appearance.

16¹. Surface apparently slightly etched around and between edges of grains.

10¹. About the same, except that the marking was not as prominent.

4¹. Form of grain not as clearly defined; rusty in appearance, with some bright spots; dense resinous-like film surrounding mass; tendency to rust on polished portion; roughening of surface very perceptible.

New Troisdorf, plates 17¹, 11, 11¹, 5¹. Outline of grains sharply defined by dark flocculent substance inclosing blotches of a gray color; the film surrounding the mass had the appearance of fine bubbles. The background had a fused appearance.

17¹. Surface somewhat etched; form of grain not very clearly defined; resinous film on plate.

11¹. Form of grain more definite; etching quite faint.

5¹. Rusty appearance; corrosion of surface very perceptible to touch; resinous-like film about edges; tendency to rust on polished surface.

New Rifleite, plates 18¹, 12, 12¹, 6¹. Outlines of grains not very definitely indicated; general color yellowish gray; resinous film, with yellow globules covered by black feathery particles.

18¹. Surface very finely etched, with a few irregular black spots.

12¹. In a similar condition, except that the form of grains was more distinctly indicated and the surface somewhat darker.

6¹. Corrosion very apparent to touch; dark rusty spots; resinous-like film about edge; tendency to rust on polished surface.

From the few foregoing tests it would appear that when burned in the open air the gun-cotton powders had the most injurious effect on steel; this is still more noticeable when the residue is allowed to remain undisturbed for some time.

LABORATORY EXPOSURE.

The powders were exposed in the dark, in shallow pasteboard boxes on plates of cartridge metal, about nine months.

Peyton, unglazed.—Exposed about nine months. Lost 3.08 per cent in weight; grains on surface generally were covered with a yellowish efflorescence; those beneath became lighter on edges.

Plate.—The form of grain was marked in yellow, with a dark background.

The exudation was partly soluble in water, which solution gave whitish residue.

Peyton, glazed.—Exposed nine months. Lost 2.08 per cent in weight. Some grains entirely covered with greenish-yellow efflorescence, others showed sparkling white spots. General appearance dull.

Plate.—Similar to preceding.

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Leonard, J., small.—Exposed nine months. Lost 3.30 per cent in weight; became of a rich dark claret color with whitish efflorescence (like mold).

Plate.—Dark greenish-yellow spots with lighter background, not much affected.

Leonard, N., small.—Exposed nine months. Lost 0.34 per cent in weight; decidedly faded in appearance; some grains of a lemon color, rather softer.

Plate.—Form of grain marked in dark red with reddish-brown background.

Leonard, N., 7/16.—Exposed eight months. Lost 2½ per cent in weight. Grain became harder, less oily, slightly darker.

Plate darkened where grains had been in contact.

New Wetteren.—Exposed eight and a half months. Lost 0.18 per cent in weight. No apparent change except a trifle lighter at edges.

Plate.—Position of grains indicated by slight darkening; not affected where grains were in contact; background darkened.

Troisdorf, I.—Exposed eight months. Gained 0.53 per cent in weight; no apparent change.

Plate not noticeably affected.

New rifleite.—Exposed eight and a half months. Lost 1.58 per cent in weight. No apparent change.

Plate not affected.

B. N. F.—Exposed eight and a half months. Lost 0.19 per cent in weight. Grains somewhat faded; edges lighter. Grains faintly outlined on plate by darker background.

New Troisdorf.—Exposed eight months. Gained 0.38 per cent in weight. No apparent change.

Plate not affected.

Very respectfully,

J. PITMAN,
Captain, Ordnance Department.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.
(Through the commanding officer, Frankford Arsenal.)

(1736)

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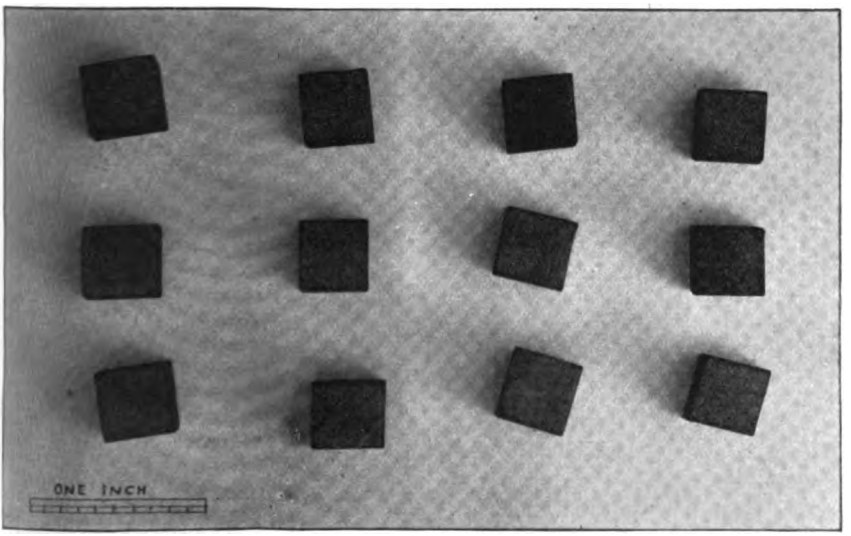

Appendix 10.

GERMAN (CUBICAL) SMOKELESS POWDER.

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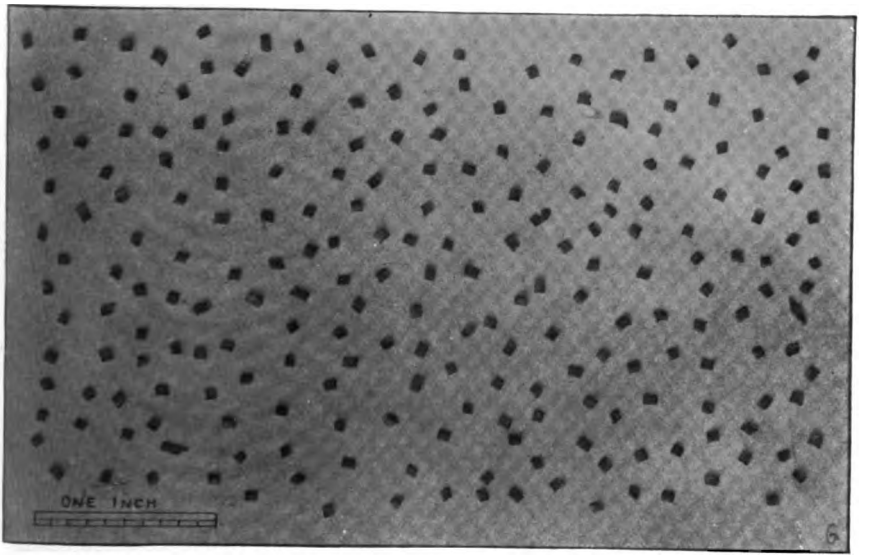

TROISDORF No. 1.

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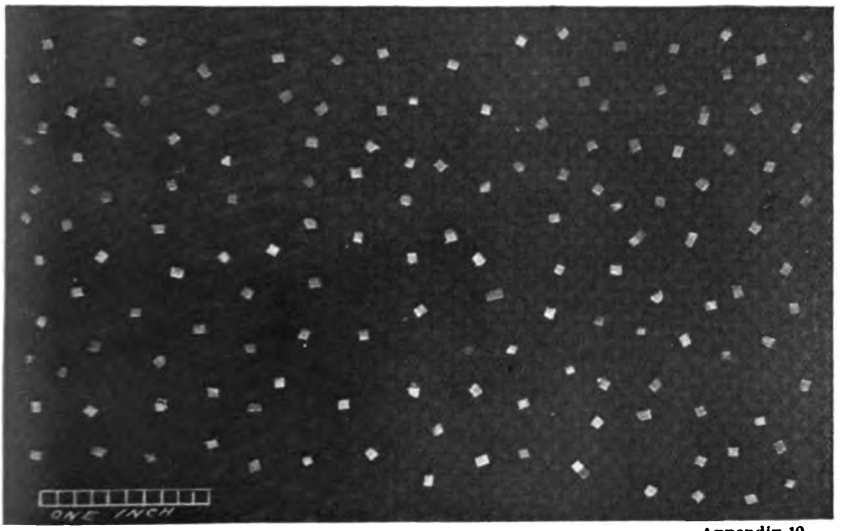

Appendix 10.

NEW WETTEREN POWDER.

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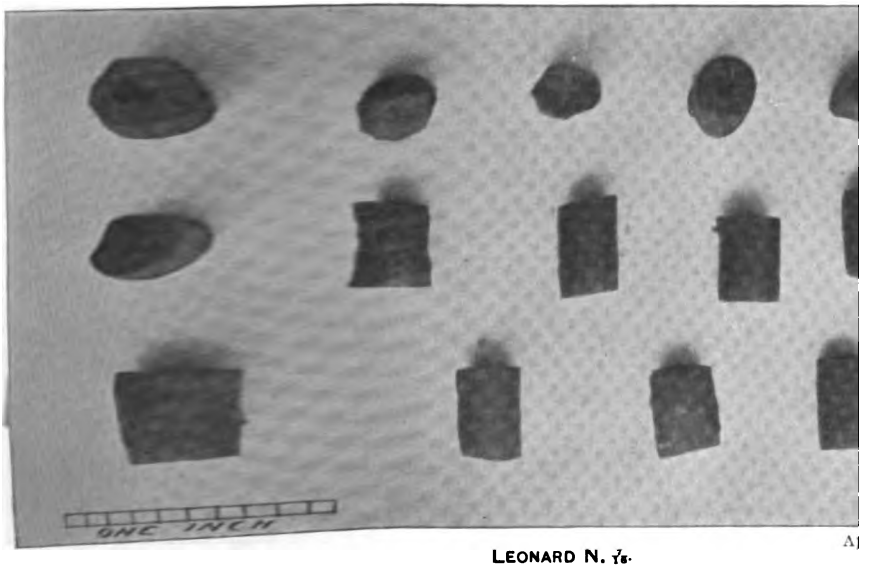

LEONARD N. ⅞.

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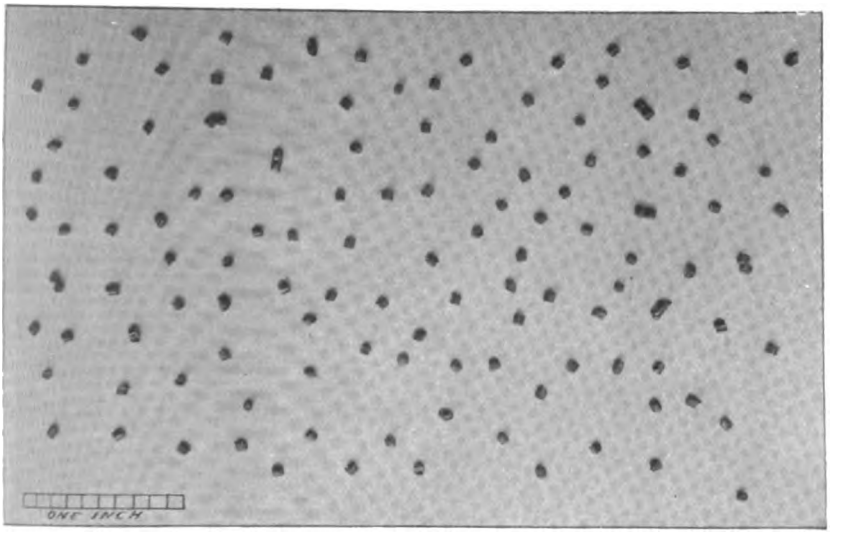
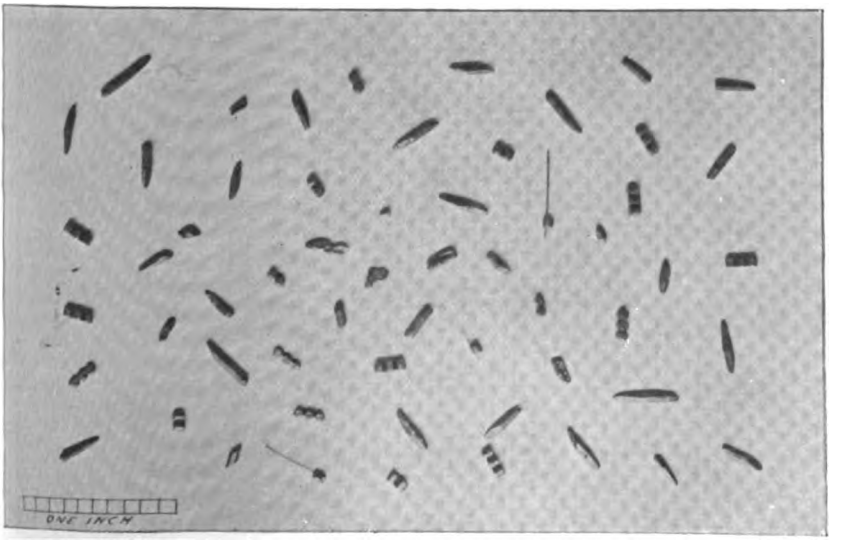


PEYTON POWDER (CONTRACT).



PEYTON POWDER (ODD GRAINS).

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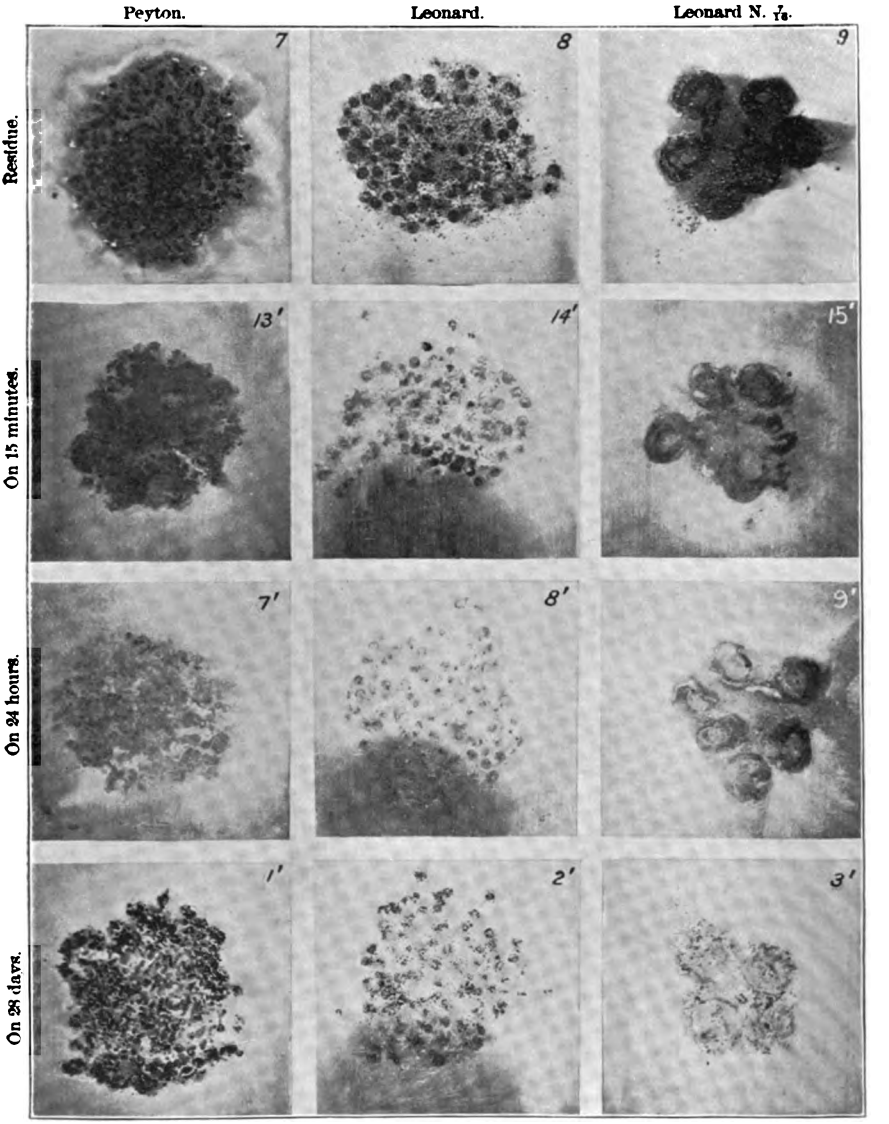

Appendix 10.

NITRO-GLYCERINE POWDERS.

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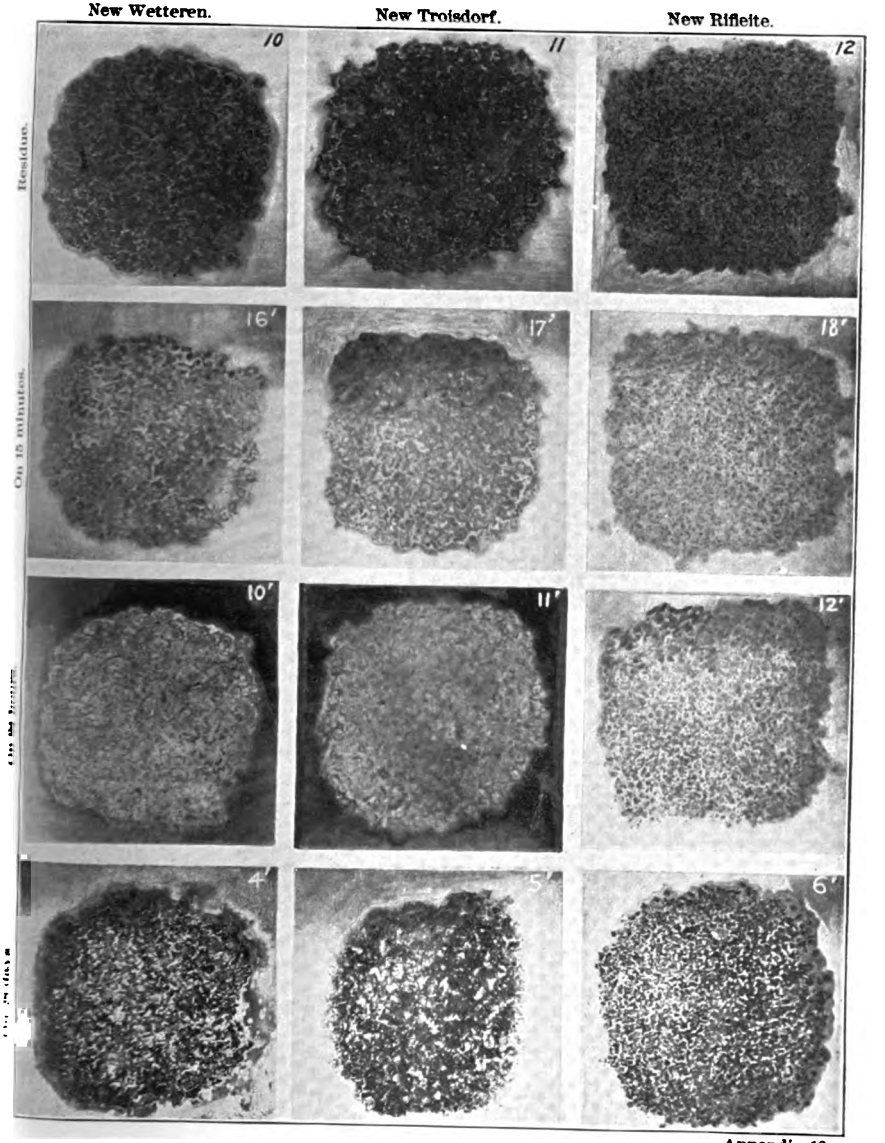

NON-NITROGLYCERINE POWDERS.

Appendix 10.

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APPENDIX 11.

DESCRIPTION OF ECCENTRIC CALIPER FOR ARMOR-PIERCING PROJECTILES, CALIBERS 8, 10, AND 12 INCHES.

(1 plate.)

FRANKFORD ARSENAL, *May, 1894.*

INSPECTING INSTRUMENTS.

On account of the conical shape of the cavity in the armor-piercing projectiles, ordinary appliances or calipers can not be used to measure with accuracy the eccentricity of the shot in their inspection. The following description of an eccentric caliper for armor-piercing projectiles relates to one devised for this purpose as proposed from this office and constructed at the Frankford Arsenal, where also the details of construction were prepared. Instruments of this description have been issued to inspecting officers and found to be convenient and satisfactory, except in the wear of the bronze centering wheels, which will hereafter be hooped with harder material. The instrument being once fixed to a shell, the revolution of the measuring arm will record on an enlarged scale (dial-shaped) the distance from the axis of the projectile to the point on the exterior surface where the measuring point is in contact. By revolving it wholly around the difference of radii to the exterior surface is observed, and gives a measure of the eccentricity of the shot. The measuring arm is made of aluminum; one of these is provided for each caliber of shot, and these arms are interchangeable on the instrument.

The caliper is designed to measure eccentricity of exterior radii of hollow projectiles with reference to the axis of the cavity in projectile, the limits being regulated by scale and index. (*See* accompanying drawing.)

The caliper consists of one hollow steel axle, A, with aluminum handle; one aluminum measuring arm, B, for each caliber; two centering wheels, C, D, for each caliber; one fixture, E, carrying a measuring point and lever index for attachment to the end of the measuring arm; one brass tube, F, to hold standard, etc.; one standard, G, with three radial points, h, h^1, h^2, for adjustment of caliper.

TO ASSEMBLE THE CALIPER.

Remove end nut a and washer b of axle, holding the axle upright by the handle, with its end resting on a table. The required measuring arm, previously fitted with measuring-point attachment E by means of a nut, c, for this purpose on each arm, is slipped on the axle A until it rests on the steel collar d of the axle, the heads of the three screws e on the measuring arm passing through the slotted holes f

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in the collar. After this, the measuring arm, being turned to th hand, will be brought to a stop by the slots *f* and can then be sec fastened to the collar by a slight turn of each of the three scre The larger of the two centering wheels C of the set required is slipped on the axle A. After this the brass tube F, with its c downward, follows on the axle until it comes to a bearing. Lastly small wheel D is adjusted in place and fastened with washer *b* nut *a* on end of axle A.

ADJUSTMENT OF THE CALIPER.

For testing the adjustment of the caliper a steel standard, G, is vided. It consists of a hub, *g*, with three radial pins, *h*, h^1, h^2, on each caliber. This is screwed on the collar end of the brass tub and the latter slipped on the axle, A (for this adjustment), with of brass tube in the reverse of their usual position, as described ab The measuring arm has then its measuring point, *i*, brought to bea on the corresponding radial pin of the standard. In this position index, *k*, should be at zero of the scale, and the caliper is in pr adjustment. If it is not, the measuring point, *i*, must be screwe or out while in contact with the radial pin, *h*, of the standard t the index points to zero of the scale. After adjustment remove standard, G, and reverse the brass tube, F, the remaining parts b assembled as first described above.

INSERTING AND USING CALIPER IN SHOT.

Hold the assembled caliper by the handle with one hand and the of the measuring arm with the other hand. At the same time p back the measuring point, *i*, to avoid injuring it, as the axle, A, centering wheels, C, D, is entered into the cavity of projectile u the measuring point is past the band of projectile. When the sm wheel, D, comes to a firm bearing in the cavity the large wheel, C, viously free to move a distance along the axle, A, is brought to a bearing in the cavity, thus centering the axle, after which it or the jectile may be rotated by the handle to carry the measuring arm and its point, *i*, around the exterior surface of the projectile, read the measurements on the scale which magnifies the motion of the m uring point in the ratio 5 to 1 of the lever arms, *j*, of the index.

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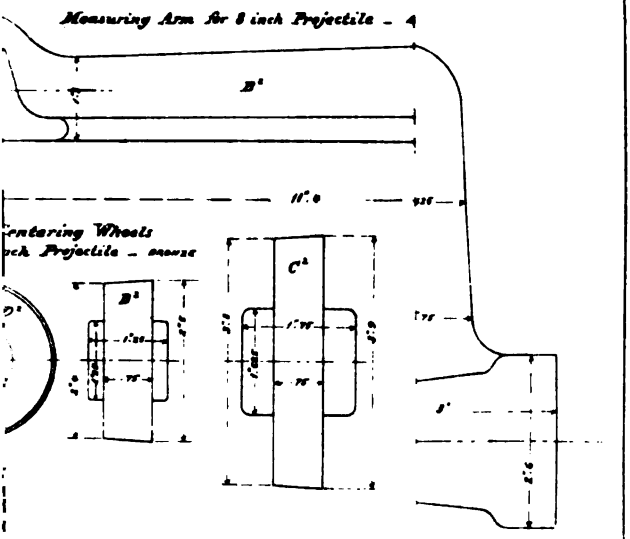

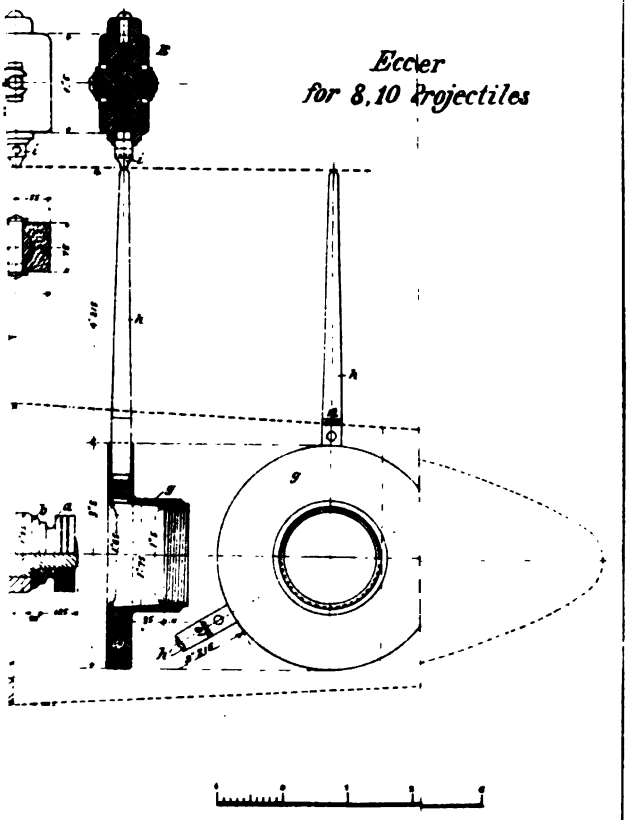

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APPENDIX 12.

REPORT UPON THE MANUFACTURE, ETC., OF CRUSHER GAUGES.

(5 plates.)

FRANKFORD ARSENAL, *July 3, 1894.*

The gauges are of two kinds, fixed and internal, each kind being ade in two sizes, large and small.

FIXED CRUSHER GAUGE (LARGE). PLATE I.

Parts.—1. The housing (*a*). 2. Closing screw cap (*g*). 3. The piston). 4. Cylinder holder (*d*). 5. Copper washer (*c*). 6. Cup gas check). 7. Pressure cylinder (*f*). 8. Blank plug (*h*), to be used when essures are not taken.

Tools.—1. Hexagonal wrench (bronze) (B). 2. Hexagonal wrench teel) (D). 3. Gas-check inserting tool (A). 4. Hand pliers (C).

The fixed crusher gauge (small) has the same parts and tools, except- g there is no closing screw cap and no steel hexagonal wrench. late II.)

INTERNAL CRUSHER GAUGE (LARGE). PLATE III.

Parts.—1. Housing (*a*). 2. Closing screw cap (*g*). 3. Piston (*b*). 4. asher (*c*). 5. Cylinder holder (*d*). 6. Cup gas check (*e*). 7. Press- e cylinder (*f*).

Tools.—1. Hexagonal wrench (B). 2. Pin wrench (D). 3. Gas-check serting tool (A). 4. Pliers (C).

The internal crusher gauge (small) has the same parts and tools, xcept a screw-driver is substituted for the pin wrench. (Plate IV.)

METALS USED.

The housings of the large gauges are made from Sanderson's bar steel o. 6, double-extra hammered and annealed; the pistons, closing screw ps, cylinder holders, and all the steel parts of the small gauges from obson's choice extra best bar steel; the blank plug of the fixed usher gauges from machinery steel, and the cup gas checks and ashers from sheet copper. The pressure cylinders are made from cop- er alloy of the approximate proportions of 93 parts copper to 7 of zinc. he rod is drawn once after annealing, and every precaution in compo- tion and treatment is taken to have the metal homogeneous.

TESTS OF METAL.

The steels are of standard brands and are subjected to the usual tests nd inspections upon their receipt at the arsenal. The sheet copper is

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inspected for thickness and general appearance. Before accepting a lot of metal intended for pressure cylinders a sample is furnished to Watertown Arsenal, where, in a testing machine, they are subjected to compression. If the results are sufficiently uniform the lot of metal is accepted. From these results a table of pressures and lengths is compiled for use with the cylinders made from that particular lot of metal.

MANUFACTURE OF FIXED GAUGE HOUSING.

It is first cut to length in cutting-off machine. It is then placed in a lathe and chucked where—

(1) An axial hole is drilled—diameter slightly less than that of the piston.

(2) This hole is reamed to proper diameter—its upper part forms the piston chamber.

(3) Counterbored to a diameter slightly less than that of the piston head, and to a depth sufficient to form piston-head chamber.

(4) Counterbored for the interior thread.

(5) These two chambers reamed to size.

(6) Interior thread cut—forms seat of closing cap screw. The housing is then taken out of chuck and placed on centers.

(7) Exterior turned to size and general shape.

(8) Exterior thread cut.

The housing is then placed in a milling machine, and the head given ts hexagonal shape.

The piston and piston-head chambers are now ground out. This is done by chucking a copper rod, applying emery to it, and running the housing on and off.

The blank plug is of the same exterior as the housing and is similarly formed.

SCREW CAP.

A bar of steel is placed in a screw machine where—

(1) The end is turned to general form.

(2) Thread is cut.

(3) Cut to length.

The cap is then placed in a milling machine, where the head is formed. From here it goes to a drill press where the two small holes are made.

PISTON.

It is first cut to a length slightly greater than the proper one, in a cutting-off machine, and then centered in a lathe, turned to its general form, and nicked in two places just outside its true extremities. It is then placed in a milling machine, where the grooves are formed. These grooves and the small holes in the closing screw cap allow the free passage of air, thus permitting the free movement of the piston.

The metal is then hardened. It is next ground to the proper diameters on an emery wheel. The ends are now broken off, the nicks above referred to facilitating the operation. The center holes are thus gotten rid of. It is then taken to a surface grinder and ground to length.

The details of manufacture of the piston are the same for all the gauges.

CUP GAS CHECKS.

These are cut from sheet copper 1/100 inch in thickness. A double acting press cuts the disks and forms the cups. The latter are then trimmed to length on a lathe.

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COPPER CYLINDERS.

The rods are placed in a screw machine, where the cylinders are cut length. They are next annealed. Several thousand are treated at one e to insure to all the same density. This is done by placing them in a indrical receptacle, which is slowly and carefully revolved over a fur- e. This operation is continued until all are brought to a red heat, en the fire is turned and the cylinders allowed to cool, the revolution the receptacle continuing meanwhile. The proper degree of cooling ndicated by the cylinders turning black.

To clean them, they are thrown into a bath of water and sulphuric l—about 40 to 1—after which they are washed in clean water to ove all traces of the acid. They are then placed in the dry house and roughly dried.

After this the cylinders are passed through a die to give them the per diameter, and then, on a lathe, are squared to length.

CYLINDER HOLDERS.

These are made from a steel bar. The first three operations are per- med on a lathe, viz:

1) Drilling hole to proper diameter through the length of bar.
2) Turning to proper exterior diameter.
3) Cutting to length.

The holders are then passed to a drill press, where the two rivet holes made. The springs are made from springy steel. They are cut to gth, bent to shape, and riveted in place, all by hand.

COPPER WASHER.

These are cut out of sheet copper and then annealed.

STEEL WRENCH.

These are cut out of sheet steel.

BRONZE WRENCH.

These are purchased in the roughly cast form and finished at the enal.

GAS CHECK INSERTING TOOL.

These are made from brass rods. They are first cut to length and erwards inserted into and fastened to the handles.

PLIERS.

These are bought ready for use.

MANUFACTURE OF INTERNAL GAUGE.

HOUSING.

The operations and machines used are the same as for the housing of fixed gauge excepting a grooved outer surface is substituted for the erior screw thread. In addition there are two grooves cut in sur- e in contact with head of closing screw cap. These, with the corre- nding grooves in the closing screw cap, serve to make a more perfect s check.

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CLOSING SCREW CAP.

This is made the same as the corresponding part in the fixed gauge, omitting the two holes for the passage of air. In addition there are two holes sunk in the outer surfaces of the head to receive the pins of the pin wrench. The other parts and tools, with one exception, are the same as for the fixed gauge.

THE PIN WRENCH.

This is received at the arsenal cast; it is then cleaned and finished. The pins are cut to length from steel wire and driven into place by hand.

MANUFACTURE OF FIXED GAUGE (SMALL).

The details of this are the same as those of the large one except that no interior thread is cut and no pressure cylinder chamber is made in the housing.

MANUFACTURE OF INTERNAL GAUGE (SMALL).

The operations are the same as for the large gauge except that no grooves are made on the housing and closing screw cap and the latter is slotted for a screw-driver instead of having the holes for the pin wrench. Instead of the steel cylinder holder a rubber one is used and this is punched out of sheet rubber.

The screw-driver is cut to length from round bar steel and then in a milling machine the tongue is formed.

INSPECTION.

All the parts are inspected for dimensions, using standard gauges; the threads examined, using standard nuts; the components carefully adjusted to one another. (Pl. V.)

In testing the piston chamber the piston itself is used, the latter having previously been verified as to dimensions. The piston is further subjected to a pressure of 6,000 pounds (a greater pressure than it is destined to withstand), any alteration in dimensions causing its rejection.

Respectfully submitted.

CHAS. C. WALCUTT, JR.,
First Lieutenant, Eighth Cavalry.

FRANKFORD ARSENAL,
Philadelphia, Pa., July 3, 1894.

Approved and respectfully forwarded to the Chief of Ordnance, U. S. Army, in connection with O. O. file No. 3828, 1893.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, Commanding.

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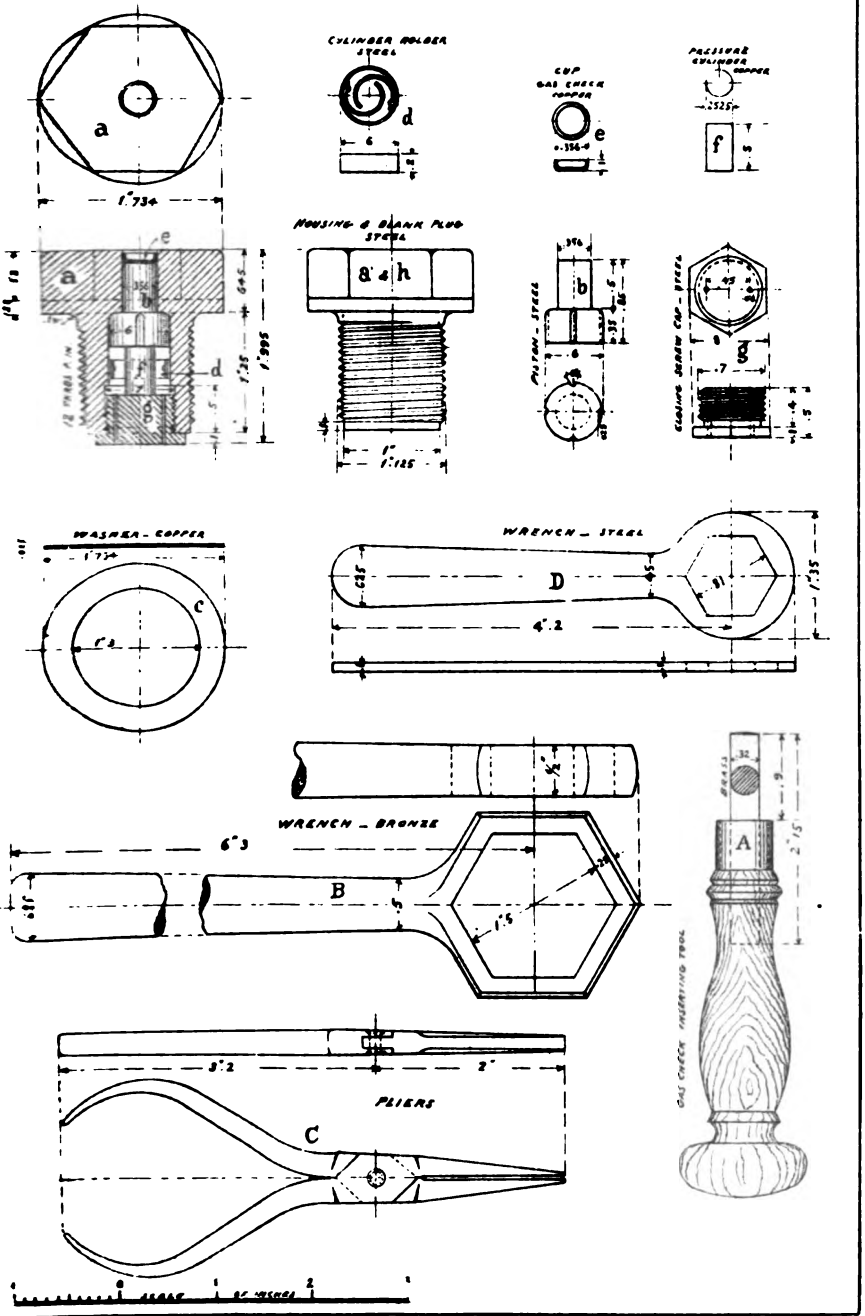
Fixed Crusher Gauge for Cannon - large

USE – FOR SEA COAST B.L. GUNS



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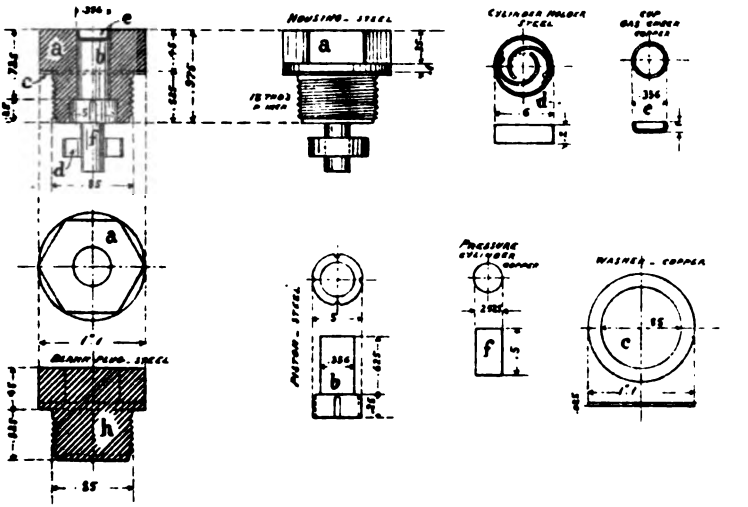
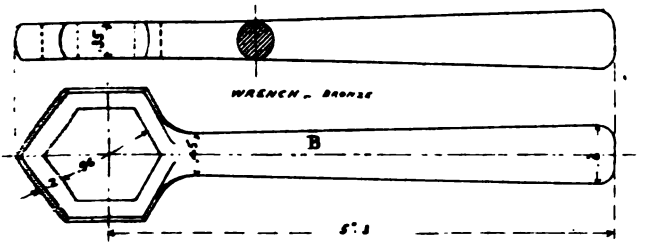
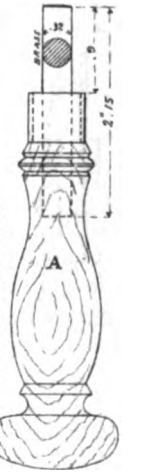
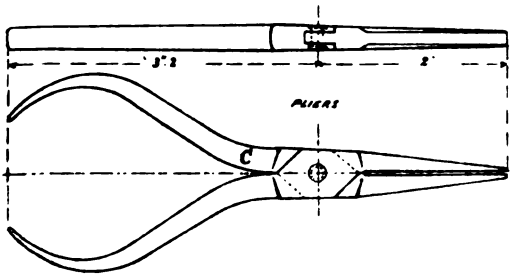
Fixed Crusher Gauge for Cannon - small

USE { FOR B.L. FIELD GUNS WITH RADIAL VENT AND FOR 5 INS. AND 7 INS. SIEGE GUNS - THE GAUGE BEING SEATED IN HEAD OF BREECH BLOCK SPINDLE









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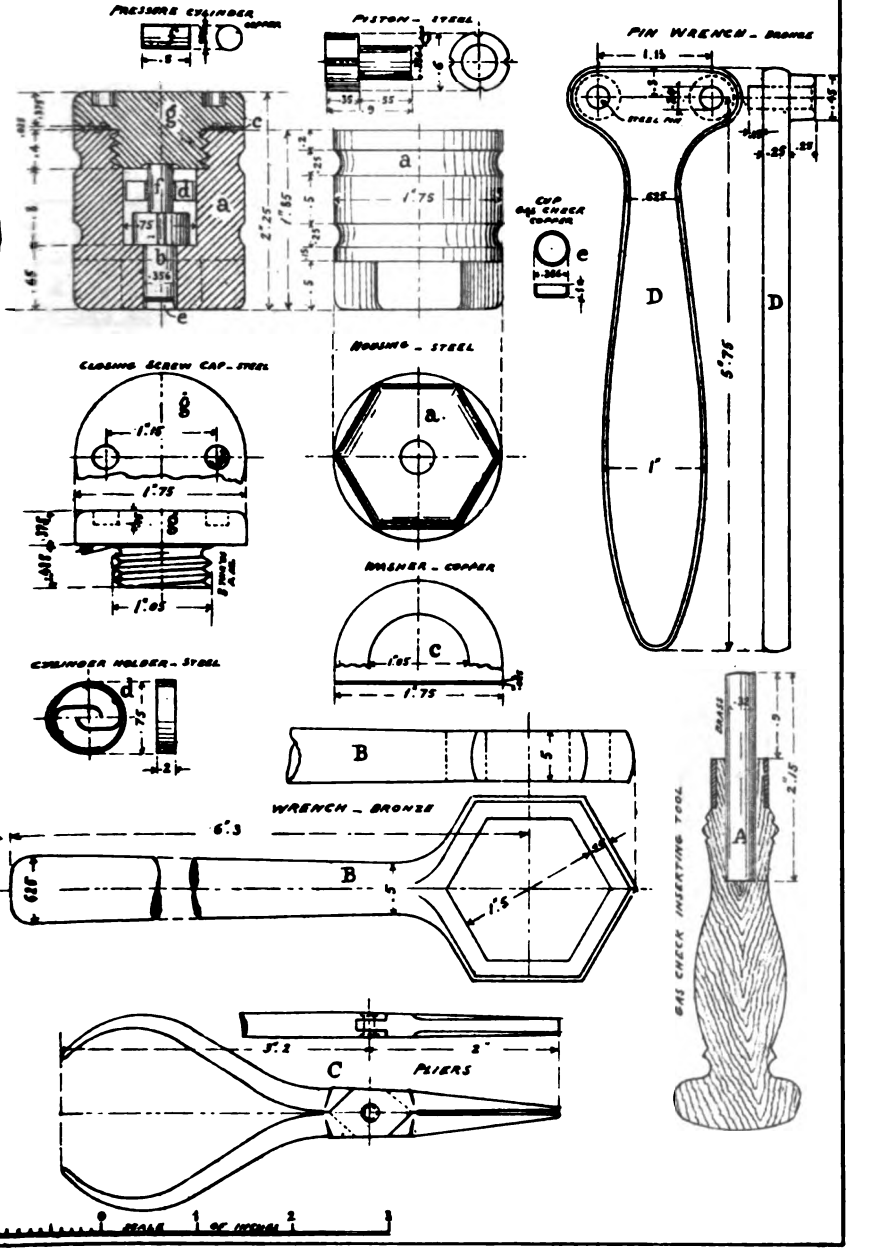
Internal Crusher Gauge for Cannon - large

USE { FOR M.L. CANNON OF LARGE CALIBRE IN GENERAL AND CHIEFLY (AT PRESENT) FOR ARTILLERY POSTS WITH SMOOTH BORE GUNS - MAY ALSO BE USED IN B.L. GUNS OF LARGE CALIBRE IN LIEU OF FIXED GAUGE.



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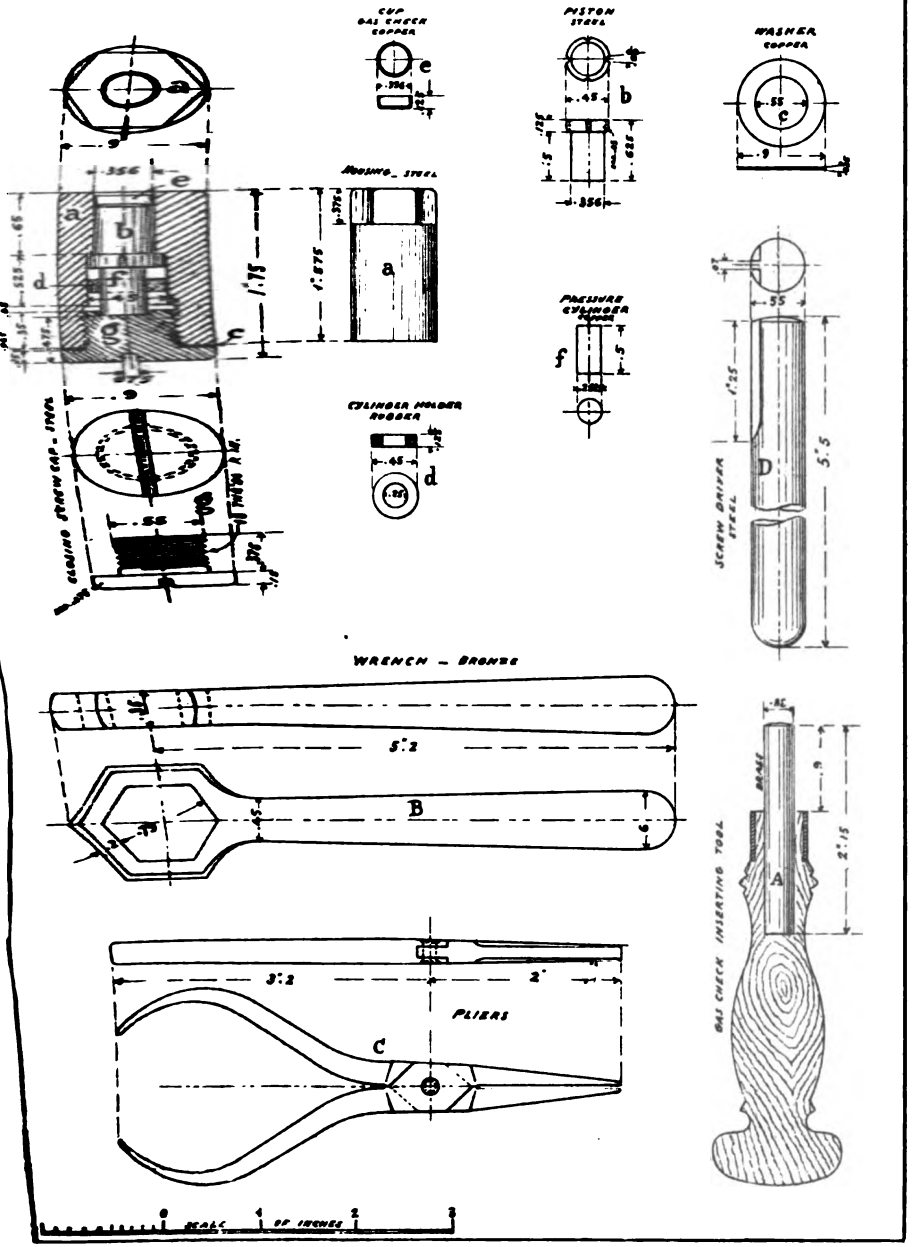
Internal Crusher Gauge for Cannon - small

USE { FOR B.L. FIELD GUNS AND MORTARS - ESPECIALLY THOSE WITH AXIAL VENT IN WHICH FIXED GAUGE CANNOT BE SEATED - MAY ALSO BE USED FOR 5 AND 7 INCH B.L. SIEGE PIECES IN PLACE OF FIXED GAUGE - AND FOR M.L. FIELD PIECES IN GENERAL



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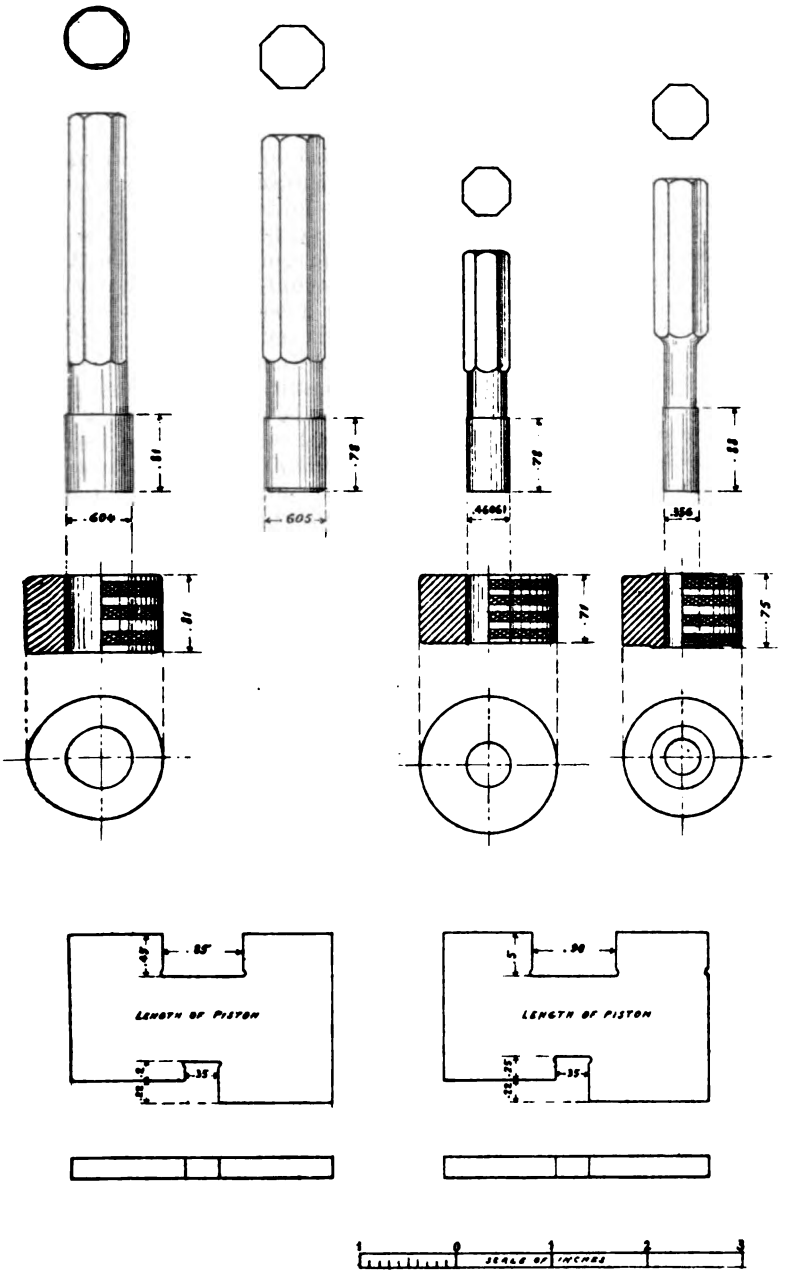
Gauges for verifying dimensions of Parts of Crusher Gauges



Appendix 12, 1894.

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APPENDIX 13.

TESTS OF BLACK AND SMOKELESS POWDERS AT BENICIA ARSENAL, DURING 1893 AND TO JUNE 30, 1894.

As stated in the report of the Chief of Ordnance for 1893, the facilities at this post for making ballistic and other tests have been increased by the construction of an instrument house and bomb proof at the proving ground, and by the addition to the testing instruments of a Le Boulengé chronograph of latest pattern. The small-arms testing apparatus now includes a rifle and pressure barrel of .45 caliber, a rifle with Springfield breech mechanism and a pressure barrel, both of .30 caliber, and a United States magazine rifle of the same caliber recently received. The small-arms testing gallery has been improved by the removal of the instrument room from the east end of the gallery, where it was too far removed from the loading room and firing stand at the west end, to a position at the side of the building convenient to both. The new position greatly facilitates the work of making tests or experiments, as it enables the officer at the instruments to exercise constant supervision over all preparations and over all the details of the work. The batteries stand in the instrument room. Piers for two velocity instruments have been built independent of the building, and two sets of wires lead from the instruments to the muzzle of the gun and to the second target. Both instruments can thus be used at once. In this gallery all tests with small arms, except those for accuracy, are made. For the latter test a range of 500 yards over water is provided at the proving ground, the firing stand being in a building on the wharf, which contains a rest or vise for holding the piece.

At the proving ground twelve lines of copper wire lead from the new instrument house to the firing ground. These provide the circuits for two velocity instruments, for signal bells, firing batteries, and the like. All tests with field guns are made here; the present equipment consisting of a 3-inch muzzle-loading rifle and a 3.2-inch breech-loading rifle. Tests of powder for pieces of larger caliber are made at Fort Winfield Scott, San Francisco. An 8-inch converted rifle is mounted on its carriage at the proving ground, but the platform is worn out and the piece can not be fired. Timber is on hand for the construction of a new platform. It is contemplated to change the location of the platform for this piece so that the firing will be made over a small marsh into a side hill, instead of over the bay as heretofore.

The firing during the year has consisted of tests of powder for the various arms and of bullets for the .30-caliber rifle. The powder tests have been principally of powder furnished under contract by the California Powder Works at Santa Cruz for small arms and cannon and of smokeless powders invented and manufactured on this coast.

Under instructions from the Ordnance Office, received January 30, 1893, I was charged with the duty of entering into correspondence with the manufacturers of explosives on this coast, for the purpose of informing them of the desire of the department to afford every facility

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that might aid in the development of powder manufacture here, and also with the duty of carrying out the necessary experiments with the articles submitted. A circular letter was sent to seventeen manufacturers or inventors of powders and projectiles, informing them of the desire of the department to assist in every way practicable in the manufacture of powders and explosives for use in guns and projectiles, stating that suitable smokeless powders for all guns were especially desired, that every facility for testing would be afforded at this arsenal, and that, when practicable, an officer from the arsenal would be present at private tests. Correspondence on the subject was invited. Replies to this circular were received from four manufacturers only, and two of these answered that the products of their works consisted of high and low explosives for blasting purposes only. Other manufacturers or inventors were visited in person.

Three smokeless powders have been developed on the coast and tested at this arsenal; of these 2 are being manufactured now. The manufacturers of the third, not having met with success in the production of a powder suitable for use in rifles, have turned their attention toward the development of a successful shotgun powder.

TESTS OF BLACK POWDERS.

These powders are all made by the California Powder Works at Santa Cruz, the principal gunpowder factory on the Pacific coast.

The following tables exhibit the results of the tests, the final test only of each kind, which resulted in the acceptance of the powder, being tabulated. In some cases as many as four lots of the powder were tested at different times before one was obtained possessing the requisite qualities.

SMALL-ARMS POWDER FOR SPRINGFIELD RIFLE, CALIBER .45.

[Requirements: Charge, 69 grains; bullet, 500 grains; velocity, 1,270 feet; pressure, 30,000 pounds; radius of circle at 500 yards, 0.8 feet; granulation, 0.03—0.06 inches; density, 1.75—1.8.]

Date of contract.	Date of final test.	Mean velocity.	Mean. pressure.	Radius of circle at 500 yards.	Granulations.	Density.
		Feet.		*Foot.*	*Inch.*	
Sept. 17, 1892	Feb. 18, 1893	1,287.7	33,066	0.49	0.03—0.06	1.82
May 17, 1894*	Jan. 15, 1894	1,258	26,000	.....	.....	.....

* Rejected.

MORTAR POWDER FOR 3-INCH M. L. RIFLE.

[Requirements: Charge, 1½ pounds; projectile, 9½ pounds; velocity, 1,280–1,310 feet; pressure, 28,000 pounds; variation in velocity, 5 shots, not to exceed 7 feet; granulation, 0.06–0.10 inch; density, 1.75.]

Date of contract.	Date of final test.	Mean velocity.	Mean pressure.	Variation in velocity.	Granulation.	Density.	Remarks.
		Feet.	*Pounds.*	*Feet.*	*Inch.*		
Sept. 17, 1892	Feb. 16, 1893	1,344	34,400	13	0.06–0.10	1.75	Lot 1.
		1,348	33,200	7	0.06–0.10	1.75	Lot 2.
Sept. 20, 1893	Oct. 19, 1893	1,343	26,295	13	.....	.....	Lot 1.
		1,326	27,428	18.6	0.06–0.10	1.77	Lot 2.
		1,336	26,008	8.4	.....	.....	Lot 3.
		1,336	26,084	11.75	.....	.....	Lot 4.

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I. K. POWDER FOR 3.2-INCH B. L. RIFLE.

[Requirements: Charge, 3¼ pounds; projectile, 13¼ pounds; velocity, 1,670–1,690 feet; pressure, 36,000 pounds; mean variation in velocity not to exceed 7 feet; granulation, 2,000 to the pound; density 1.725.]

Date of contract.	Date of final test.	Mean velocity.	Mean pressure.	Mean variation in velocity.	Granulation.	Density.	Remarks.
		Feet.	*Pounds.*	*Feet.*			
Sept. 20, 1893	Dec. 15, 1893	1,708	35,634	4	2,096 to 1 lb...	1.75	Lot 1.
		1,713	35,860	8	1,984 to 1 lb...	1.74	Lot 2.

SPHERO-HEXAGONAL POWDER FOR 3.2-INCH B. L. RIFLE.

[Requirements: Charge, 3¼ pounds; projectile, 13¼ pounds; velocity, 1,670–1,690 feet; pressure, 35,000 pounds; mean variation in velocity not to exceed 7 feet; granulation, 122 to the pound; density, 1.7.]

Date of contract.	Date of final test.	Mean velocity.	Mean pressure.	Mean variation in velocity.	Granulation.	Density.	Remarks.
		Feet.	*Pounds.*	*Feet.*			
Mar. 16, 1894	June 22, 1894	1,651	31,740	4.4	115 to 1 lb	1.69	(*)

* Accepted, subject to the approval of the Chief of Ordnance.

HEXAGONAL POWDER FOR 15-INCH S. B. CANNON.

[Requirements: Charge, 130 pounds; projectile, 452 pounds; velocity, 1,675-1,700 feet; pressure, 22,000-25,000 pounds; granulation, 72 to the pound; density, 1.75.]

Date of contract.	Date of final test.	Mean velocity.	Mean pressure.	Granulation.	Density.
		Feet.	*Pounds.*		
Feb. 22, 1893	Oct. 12, 1893	1,664	26,945	71 to 1 pound	1.77
Feb. 17, 1894	Apr. 16, 1894	1,685	27,308	70 to 1 pound	1.76

SMOKELESS POWDERS.

UNITED STATES SMOKELESS POWDER.

This powder is made by the United States Smokeless Powder Company, of San Francisco. Their works consist at present of a laboratory only, situated about 6 miles from San Francisco, where the powder is made by hand. It is the intention of the company to erect works for the manufacture of the powder in quantity, and they are looking for a suitable site in this vicinity. The powder, as originally made, was composed of ammonium picrate and ammonium nitrate, in proportions varying from 1 to 3, to 1 to 7. This compound absorbed moisture very readily. The powder, as now made, is a mechanical mixture composed of ammonium picrate, potassium picrate, and ammonium bichromate. For rifles its density is from 1.6 to 1.75; for shotguns from 1.8 to 2. It is yellow in color, burns slowly with a yellow flame, leaving a light, feathery-green residue of chromic oxide, harmless in nature; the grains are hard and very friable, being easily reduced to powder by pressure of the fingers.

When fired the smoke and residue is slight, but in some of the tests quantities of ammoniacal gas were evolved, giving off disagreeable

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odors and affecting unpleasantly the throat, nose, and eyes. The company claim now to have succeeded in getting rid of those obnoxious effects. By reason of the lack of proper appliances, they have for the present given up experimenting with rifle powder and have turned their attention toward the development of a superior shotgun powder. In this they have been very successful.

The following table exhibits the steps made in the development of the rifle powder. Tests of numerous other samples were made, but the table includes only the results given by the most successful sample tested on the date given:

Date.	Designation of powder.	Caliber of rifle.	Charge.	Bullet.	Mean velocity.	Mean pressure.	Remarks.
			Grains.	*Grains.*	*Feet.*	*Pounds.*	
Jan. 15, 1893	No. 28.....	45	35	500	1,309	44,000	Much residue.
Aug. 23, 1893	95, coarse.....	45	35	500	1,230	30,300	Very irregular.
Do.....	....do	30	35	220	1,768	54,900	
Oct. 27, 1893	G. 28.....	30	35	220	1,808	43,405	Disagreeable odor.
Dec. 4, 1893	No. 32.....	30	40	220	1,724	52,000	Odor not so strong.
Dec. 18, 1893	G. 55.....	30	40	220	1,803	55,330	Strong smell of ammonia.
Mar. 12, 1894	G. 55, rifle	30	37	220	1,734	42,500	Slight smell of ammonia.

The company has recently submitted samples of powder for use in the field guns. The powder is of the same composition as that for shotguns and rifles. The grains are irregular in shape, and sized by sieves of 6 and 8 meshes to the inch. They are much harder and less easily broken up than the grains of rifle powder.

Tests were made with the 3-inch M. L. rifle and with the 3.2-inch B. L. rifle. In the former only one round was fired, a charge of 12 ounces being used. This gave a pressure of less than 25,000 pounds. The discharge was accompanied by a thick cloud of dark green smoke, due to the imperfect burning of the powder. After firing particles of unburned powder were found in the bore.

In the 3.2-inch B. L. rifle more satisfactory results were obtained. The smoke was much less in quantity and lighter in color, and was soon dissipated. A thin layer of a rather hard residue was left in the piece. This did not seem to be added to by the successive rounds, there being apparently no more at the end of the firing than after the first round.

No charge of priming powder was used in the cartridges.

The table exhibits the results of the firing in the 3.2-inch B. L. rifle. The projectiles used were weighted up to 13½ pounds.

Date.	Powder.	Charge.	Velocity.	Pressure.
1894.		*Lbs. ozs.*	*Feet.*	*Pounds.*
July 18	G. 84.....	1 8	1,531	29,900
		2 0	1,842	60,000
		1 12	1,683	44,500
	G. 35.....	1 8	1,543	35,600
		1 10	1,627	39,100
		1 12	1,700	53,200

GIANT SMOKELESS POWDER.

This powder is manufactured by the Giant Powder Company of San Francisco. The works of the company are situated at Giant, a station on the Southern Pacific Railway, and on the shores of the bay, about 20 miles from San Francisco. Other works are situated at Clipper Gap, near Auburn, Cal. Their principal products are dynamite of all grades for mining and blasting purposes at the former works, and black blast-

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ing powder at the latter; their capacity being 600,000 pounds of dynamite per month and 10,000 pounds of black blasting powder per day. The manufacture of smokeless powder is still in an experimental stage, but it is the purpose of the company, if this powder is successful, to enter upon the manufacture in quantity of smokeless rifle, cannon, and sporting powders, erecting works for the purpose with capacity sufficient to supply all the demand. The smokeless rifle powder, samples of which have been tested here, is dark green in color when unglazed, burns slowly when unconfined with a bright flame, giving off but little smoke, and leaving a slight residue. When fired the smoke is less in quantity and there is practically no residue, the bore being left clean and bright. The grain is approximately cubical in shape, averaging one-fourteenth of an inch on an edge.

From the table of tests which follows it will be seen that better results have been attained with this powder than with any powder yet tested here. The samples submitted have been hand-made. If similar results can be obtained from the powder when made in quantity, its outlook will be very promising:

Date.	Designation of powder.	Charge.	Pressure.	Velocity.	Mean variation in velocity.	Remarks.
		Grains.	*Pounds.*	*Feet.*	*Feet.*	
June 12, 1894	A 1.....	30	(*)	.....	.....	Powder unglazed.
		35	42,000	.....	.....	
	A 1.....	35	38,000	.....	.....	Glazed.
		38	45,500	.....	.....	
June 15, 1894	A.....	45	39,250	2,145	5.5	Velocity mean of 4 rounds.
	B.....	43	35,750	2,120	0.0	Velocity mean of 2 rounds.
	AA.....	37	41,500	2,084	36.0	Velocity mean of 3 rounds.

* Less than 35,000 pounds.

The powder charge is not ignited by the explosion of the ordinary Frankford Arsenal primer. The manufacturers of the powder supplied for use at the tests, stronger primers, said to have also been made at Frankford Arsenal.

PEYTON SMOKELESS POWDER.

Five pounds of this powder was obtained from the California Powder Works for use in ballistic tests. The powder is in small black grains, prismatic, with hexagonal section, about one-sixteenth of an inch between faces, and of irregular lengths, averaging about one-sixteenth of an inch. It is highly glazed. Unconfined it burns slowly with a bright flame and little smoke. When fired it produces a slight smoke which quickly disappears. It is without noticeable odor, and leaves little residue in the piece. The powder has been tested as follows:

Date.	Charge.	Pressure.	Date.	Charge.	Pressure.
	Grains.	*Pounds.*		*Grains.*	*Pounds.*
May 10, 1894	35	(*)	July 3, 1894	37	(*)
	38	(*)		39	(*)
	40	37,000		40	35,000
	43	36,000		42	36,000
	45	38,500		43	35,000
				45	38,600
				45	38,600
				45	38,600

* Less than 35,000 pounds.

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Five rounds fired for velocity, with a charge of 45 grains and 229 grain Frankford Arsenal bullets, gave a mean velocity of 2,031 feet, a mean variation in velocity of 24 feet, and an extreme variation from the mean velocity of 55 feet.

The powder is difficult to ignite with the present primer, as is shown by the fact that in the testing on May 10 two cartridges missed fire and one hung fire, and on July 3 two cartridges hung fire.

A small quantity of Peyton smokeless powder, furnished by Capt Reed for the tests of his bullets, gave the following results:

Date.	Charge.	Bullet.	Pressure.	Velocity.	Remarks.
	Grains.	*Grains.*	*Pounds.*		
Mar. 13, 1894	32	220	(*)	.....	
	37	.....	40,000	.....	
	40	.....	46,000	2,157	Velocity mean of 2 rounds.

*Less than 35,000 pounds.

It will be noticed that these are quite different from the results obtained later with another sample of the powder.

NEIDL SMOKELESS POWDER.

On May 20, 1893, I had an interview with Mr. Charles Bandmann, of San Francisco, who is interested with Mr. Frank Neidl, a chemist, in the invention of a smokeless powder. The powder has a gun-cotton base, and is made up into square-edged grains of a gray color. It burns slowly with a yellow flame with little smoke, and leaves but little residue. It is nonhygroscopic. Some of it was immersed in water and then dried between blotters, after which it was ignited without difficulty. It can be manufactured at a cost of 30 cents per pound in any size of grain. At Frankford Arsenal a mean velocity of 1,850 feet was obtained with a 22-grain charge of this powder, the pressure varying between 28,000 and 45,000 pounds. Mr. Bandmann informed me that he expected to receive a patent for the powder within thirty days after our interview, when he would communicate with me. Since then I have not heard from him.

Respectfully submitted.

ORMOND M. LISSAK,
Lieutenant, Ordnance Department.

BENICIA ARSENAL, CAL.,
July 19, 1894.

Approved:
L. S. BABBITT,
Lieut. Col., Ordnance Department, Commanding.

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APPENDIX 14.

REPORT OF PRINCIPAL OPERATIONS AT WATERVLIET ARSENAL FOR THE FISCAL YEAR ENDING JUNE 30, 1894.

(6 plates.)

BUILDINGS, PLANT, AND OTHER CONSTRUCTION WORK.

GUN FACTORY.

The equipment of the south wing for the manufacture of 12-inch guns has been completed during this fiscal year. All the gun lathes are erected and have been put in operation. The new style of back rests has proved entirely successful, and the manufacture of 12-inch guns has been carried on exclusively, and of the 10-inch guns partly, on such back rests. They not only insure greater accuracy of the work, but permit the machines to be kept in clean condition, and as there are no special preparations necessary for their adjustment to various diameters they save a considerable amount of labor and will help to reduce the cost of gun work in the future. It may be said, furthermore, that the amount of lubricant used with these back rests is very small. In view of the above results, the breech back rests of the first ten gun lathes in the north wing are now being provided with new rotating chuck rings of the same character as those of the gun lathes in the south wing. This work will be finished by the end of the present calendar year.

The transfer of the 12-inch gun work into the south wing and the systemization of the gun work in general, in combination with the classification of the gun lathes for the different kinds of work, has resulted in simplifying the supervision of the plant and tools, a consequent reduction in the cost of its maintenance, while accidents due to carelessness or other causes have been greatly reduced. The above improvements have had a beneficial influence on the gun work proper, which is now carried on with greater accuracy, and errors are less frequent.

Proposals were issued last year for two electric traveling cranes for the south wing, one of 60 and one of 30 tons capacity. The contract for the former was given to Manning, Maxwell & Moore for a crane of the "Shaw" type, while the contract for the 30-ton crane was awarded to the Morgan Engineering Company of Alliance, Ohio. Considerable difficulty has attended the delivery of the 60-ton crane, caused by defects in one of the girders composing the crane bridge, which were discovered at a time when the crane was almost completely assembled in the shops of the manufacturer. In accordance with instructions received from you, orders were given to have the defective girder rebuilt by removing from it all defective parts. It was stated that the girder suffered injury by dropping it in loading at the works of its builder in Pittsburg. This crane will be erected in the gun factory in September

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next. The 30-ton crane was erected in the west aisle of the south wing several months ago, and has been in continuous successful operation since. It is very simple in its construction and needs, therefore, little attendance. On account of local conditions this crane is of special design. Its construction and performance are as creditable to the Morgan Engineering Company as that of the 120-ton and the two 30-ton traveling cranes, previously furnished by this company. The new 30-ton crane is shown in plate No. 18 accompanying this report.

The contract for furnishing a portable gun scale of 300,000 pounds capacity was awarded to the Fairbanks Company. This scale was delivered some months ago. It was tested with a load equal to its full capacity, and also by arranging an unequal distribution of guns on its platform. The former test was made to determine the strength of the whole construction, the latter to test the rigidity of frame and bridge, and the reliability of the scale mechanism. The latter is so sensitive that a small piece of tissue paper, of the size of a bank note, when put on the scale beam, will disturb its balance at once. The scale is very neat in appearance. A general drawing and photographic views of it are among the inclosures.

Under the date of December 23, 1893, specifications were issued for gun lathes and other machine tools required for the equipment of the south wing. The bids were opened on January 23, 1894, and after the most careful consideration of the construction of these very important machines, a contract was entered into with the Pond Machine Tool Company for the manufacture and delivery of the following tools:

(1) Three turning and boring lathes,
(2) One turning and finishing lathe,
(3) One turning and boring lathe for jackets,
(4) One threading and slotting machine,

} For guns from 12 to 16 inches caliber.

(5) Alterations of a rifling machine to adapt it for rifling guns from 12 to 16 inches caliber.

The aggregate contract price for the above work is $206,920.

The accompanying plates Nos. 1 to 4 illustrate the principal dimensions and features of the above machines. The work on these tools has progressed favorably. The working drawings for the gun lathes are well advanced and the work on the patterns has recently begun. The greater number of parts of the 16-inch jacket lathe have been made, and this machine will be presumably assembled and delivered within a few months. Drawings for the remainder of the shafting for driving the machinery for the manufacture of 12 and 16 inch guns are under preparation. These and the specifications for the same will be forwarded at an early date.

The brickwork of the heating furnaces of the shrinkage pit has been thoroughly repaired this year, and these furnaces are now in a very satisfactory condition. The manufacture of the 40 caliber 12-inch gun, model 1892, has necessitated an extension of the jacket-heating furnace, on account of the great length of the jacket of this gun. Inasmuch as jackets of smaller calibers than 12-inch and jackets of 12-inch guns of other models than the above can be heated in the present furnace, it was found best to construct an extension to the top of this furnace, which can be easily attached for long jackets of 12 or 16 inch guns, and detached when the furnace is to be used for shorter pieces.

The present jacket furnace and its new extension are shown in the accompanying plate No. 5. It will be seen that the extension is operated on the same plan as the main furnace, i. e., by indirect heat. The extension is heated independently from the main furnace by means of a fire

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box located on the 20-foot level of the shrinkage pit. From this the hot gases ascend to an annular flue at the top of the extension, which has a number of adjustable openings on the circumference of its inner wall for the admission and uniform distribution of the hot gases into the space between the inner steel cylinder, which surrounds the jacket, and the outer fire-brick lined shell of the furnace extension. Another annular flue with openings on its inner wall is at the bottom of the extension. This collects the gases again and from it leads a flue to the chimney. The flue leading from the grate to the extension is provided with a damper or gate valve to check the flow of gases partly, or altogether, when the extension is to be removed. A similar gate valve is in the flue between the extension and the flue leading to the chimney. The extension is provided with attachments for handling it by means of one of the traveling cranes. Work on it is being pushed so as to have it ready in September next, when it will be needed.

Drawings and estimates are also under preparation for a hydraulic power press for hoop shrinkages, and they will be forwarded at an early day.

Amongst the gauges designed and manufactured for cannons the "concentricity gauges" are worthy of special mention. These gauges are used for measuring the concentricity of the main bore and powder chamber, length of the powder chamber, diameter of gas-check seat, and the uniformity of depth of the grooves of the rifling. The 8-inch gauge is shown in the accompanying plate No. 6. The accuracy and uniformity of the gun work depends in a very great measure on the revelations made by means of suitable gauges, which point out irregularities and errors in workmanship that may not be discovered otherwise, and lead toward improvements and perfections in the quality of the work produced. A considerable number of such appliances have been made during the past year.

One lathe in the field and siege department has been fitted out for the threading and slotting of breech screws in guns and on breech-blocks and breech bushings of field and siege guns. This machine was constructed here, and has been in continuous and successful operation for several months, threading breech screws in guns and on blocks with a degree of uniformity and accuracy which it is difficult to obtain otherwise.

The whole plant for the manufacture of guns is running very satisfactorily and smoothly, and no changes have been found necessary after more than three years' operation. The oil house has been provided with the necessary oil tanks and accessories for handling oil in barrels. The accompanying plate, No. 7, shows the whole arrangement. Six large circular oil tanks are placed in a row at one side. Their tops are covered with square cast-iron covers or hoppers which are slightly sloping toward the center, and with openings in the center for filling the tanks. The oil barrels are rolled into the building, and by means of a light overhead traveler and differential hoist are hoisted to the top of the tank which is to be filled, and are simply emptied. This method works very satisfactorily, especially in handling certain boring oils which become so viscous in cold weather as to make any other method for emptying the barrel except breaking in the top unsuccessful. Each oil tank has a drawcock and three gauge cocks.

Opposite these tanks are located two wooden zinc-lined oil cabinets that have been located previously in the gun shops. They are used for engine and dynamo lubricants, and for other oils of which only small quantities are needed. The soaking tank for wooden blocks to be used

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for lining up reamers is also located in this building, and sufficient room is left for the accommodation of a number of oil barrels in the center.

The building is heated by steam from the gun shop. Arrangements are made to fill the building with live steam in case of fire, by means of a valve located in the gun shop opposite the oil house.

ELECTRIC LIGHT AND POWER PLANT.

The contract for this plant, whose general features were explained in my last annual report, was awarded to the E. G. Bernard Electric Company, of Troy, N. Y., agents of the Siemens & Halske Company, of America. The system of this company offered some very important advantages, especially a reduction in the number of dynamos, and the use of a single dynamo for power purposes where two are required with the Edison system. These and other changes from the original specifications were embodied in the contract, while further changes were made in the details of the plant in the course of its construction. The system of wiring adopted for the main circuits is the tree or tapering system. The whole plant is now practically completed, but only the power part of it is in use. A temporary injunction prohibits the use of the light plant as originally specified at present, but it is to be hoped that an early settlement of the pending litigation will permit the use of electric light on this post, which is so much the more needed, as the gas-service system had to be discontinued over a year ago on account of great leakages of gas due to the corroded state of the gas mains. A small appropriation was asked for last year to replace the defective mains, and I again earnestly invite attention to the necessity of these repairs, without which the post is now practically without light.

The electric-light plant of the gun factory is now complete.

The underground circuits of the north wing have been changed to overhead, so as to avoid danger from injury to the wires, which may be caused by the washing of the floors of the gun shop.

The total electric energy at this post now comprises two 90 Kilowatt dynamos in the gun shop, and two 45 Kilowatt dynamos in the lower machine shop.

I would like to call special attention to the arrangement of the two stations and especially to the switch boards. They are of the skeleton type, and so arranged as to expose every part of the wiring, the connections, switches, and instruments to plain view. This arrangement requires naturally the best workmanship and material. The accompanying photographic plate, No. 20, represents the switch board, dynamos, etc., in the engine room of the gun shop. The accompanying map No. 8, shows the main circuits as executed.

WATER-POWER PLANT.

In my last annual report I called your attention to the deplorable condition of the water-power plant at this post. Arrangements have been prepared, with your sanction to reconstruct the turbine plant, so as to obtain about 120 to 130 horse power by water power, as against 35-horse power with the present deteriorated plant. It is expected to convert about 100-horse power into electrical energy for use in the gun shop, while the remainder of the output of the proposed new plant will be needed for operating the lower shops. If 100-horse power from this source could be made useful in the gun shop it would reduce the annua

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relay for coal about 30 per cent and therefore reduce the cost of the guns quite appreciably.

A part of the sum necessary for the new turbine plant has been already appropriated, but there is still an amount of $7,654 lacking, the need of which was explained in my annual estimate. It is hoped that this amount will be appropriated, for the sake of economy, in the gun factory.

BRIDGE, ROADS, PAVEMENTS, ETC.

The accompanying map of the arsenal, plate No. 8, shows the location of the new iron bridge across the Erie Canal, as well as the main avenue and adjacent roadways.

The contract for the new bridge, which is represented in the accompanying plates, Nos. 9 to 11, was awarded to the Pennsylvania Steel Company, and the bridge was erected several months ago. The abutments are built of concrete up to the surface and from the ground line to the top of stone masonry.

A change was made in the length of the bridge, as described in the specifications which were submitted with my last annual report, which is fully shown in the drawings. The span of the bridge has been shortened about 30 feet.

Attention is called here to an interesting operation, which is shown in the photographic plate, No. 21, accompanying this report. Heavy bank runs were put in position on the west embankment, on which the bridge was completely assembled and riveted up. After assembling and riveting, rollers were placed between the bridge girders and the bank run. By means of these and winches applied at the rear end of the bridge, the latter was moved forward until about two-thirds of its length projected beyond the abutment. The free end of the bridge was next supported by means of blocking and screw jacks on the deck of a large canal boat, and the bridge was floated across the canal in this manner to its proper place on the eastern abutment. The whole operation consumed six hours.

The most important roads at this post still need to be paved with granite blocks, especially Main avenue. But very little work could be done in this direction during the past year on account of lack of appropriations. The amount asked in my annual estimate for the paving of such roadways as give direct access to the gun factory, and others, which must be accessible for heavy teams in bad weather, and also for the filling in of low grounds, is very much needed. If Congress reappropriates the amount remaining from the paving of Broadway for use inside of the arsenal grounds, it will be possible, perhaps, to pave the whole or part of Main avenue.

It is proper to remark here that the necessary repairs to the railroad tracks inside this arsenal are a constant source of considerable expense on account of the many grades and curves and the transportation of heavy loads over same.

NEW OFFICE BUILDING.

Bids were received June 26, 1894, for the construction of a fireproof office building, for which an appropriation is available.

The increased office space and other conveniences afforded by this new building will permit the administration of the arsenal to be carried on much more comfortably and expeditiously than at present.

The building is to be located as shown on plate No. 8, and its construction is fully explained by the accompanying specifications and drawings, plates Nos. 12 to 16.

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The contract for this building was awarded to James McFerran, o West Troy, for the sum of $19,687, and it is hoped to have it finishe for occupancy next spring.

WATER SUPPLY.

The needs of an improvement of the present water supply were full explained in my last annual report, and it is to be hoped that Congres will appropriate the sum asked for at this session.

FIRE PROTECTION.

The facilities for fire protection are entirely inadequate at presen A special report, with recommendations, on this subject was recentl submitted for your consideration. The urgent necessity of an appr priation to carry out the recommendations for the efficient fire servic system proposed for the protection of Government property, the valu of which exceeds $2,000,000, is so apparent that it seems only necessar to invite especial attention to this subject.

The amount asked last year for improvements of the water suppl will furnish a part of this protection, while the amount asked for i this year's annual estimate is required principally for a powerful moder steam fire engine, a ladder truck, stationary hose reels in the shop stationary ladders for access to the roofs of the gun shops, an increase number of hydrants, an alarm system, consisting of two stations and number of alarm boxes, etc.

The following specifications were issued during the past year an copies are attached thereto:

(1) Specifications for gun lathes and other machine tools for th manufacture of guns from 12 to 16 inches caliber.

(2) Specifications for the erection of a fireproof office building..

GUN CONSTRUCTION.

The construction of field, siege, and seacoast cannon has progresse steadily and satisfactorily during the year. The number of guns mar ufactured has not been so great as the maximum capacity of the gu factory, but has been limited by the funds appropriated and availabl for gun construction; the quality of workmanship has been excelle and quite up to the high standard for accuracy which must be attaine in the manufacture of guns, and which has been continuously attaine in the work at this arsenal. A number of improvements have bee introduced, which have in view the attaining of still greater accurac in the work, and more particularly a certain interchangeability of th several parts of the breech mechanism of guns of the same caliber.

Special attention has been given to the very accurate threading c breech blocks, breech bushings and their recesses, and to the prepara tion of a complete and accurate set of templets and gauges for thi work. The threading and slotting machines have been overhaule and slightly modified and are now in most excellent condition, so tha the character of the work done on these machines, with the accessorie provided, leaves nothing to be desired.

Pending the preparation of the templets and gauges referred to, al work of threading breech blocks, breech bushings or their recesses wa suspended. This suspension has caused a temporary setback in th number of completed guns, particularly those of field and siege caliber but the accuracy which is now attained in this work has seemed s

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vitally necessary as to warrant a temporary reduction in output. Moreover, these threading machines will soon catch up with the scheduled output, and there will in the near future be a temporary increase in the number of completed guns to offset the temporary reduction in number referred to.

A summary of the work completed and that in progress at the beginning and end of the year is given in the following table:

Caliber and kind of cannon.	Construction in progress June 30, 1893.	Completed June 30, 1894.	Construction in progress June 30, 1894.
3.2-inch B. L. rifle, service	49	23	25
3.6-inch B. L. rifle, service	22	22	.....
5-inch B. L. siege rifle, service	10	.....	10
7-inch B. L. siege howitzer, service	10	.....	10
7-inch B. L. siege mortar, type	1	.....	1
8-inch B. L. seacoast rifle, service	12	11	6
10-inch B. L. seacoast rifle, service	11	11	11
10-inch B. L. rifle, Crozier, wire-wound	1	1	.....
12-inch B. L. seacoast rifle, service	6	6	7
12-inch seacoast mortar, steel, service	2	1	6

All of the cannon noted as in progress of construction are well advanced toward completion, the remaining work on many of them being only the threading, which has been delayed, and it is anticipated that nearly all should be finished by the end of the calendar year, so that the output will at that time conform very nearly to the schedule of required output which has received your approval. There will then have been completed in the gun factory since the beginning of operations 302 cannon of various calibers, viz: One hundred and twenty-seven 3.2-inch B. L. rifles, seventeen 3.6-inch B. L. mortars, twenty-five 3.6-inch B. L. rifles, twenty 5-inch B. L. rifles, twenty 7-inch B. L. howitzers, one 7-inch B. L. mortar, thirty 8-inch B. L. rifles, thirty-five 10-inch B. L. rifles (service), three 10-inch B. L. rifles (wire-wound), fifteen 12-inch B. L. rifles, eight 12-inch B. L. mortars, one 12.2-inch B. L. mortar (converted).

More work than usual has been done during the year, besides the manufacture of new service guns, in the way of alterations and fabrication of parts of guns.

The definite system of work which was introduced somewhat more than a year ago, and to which reference was made in my last annual report, has seemed to work quite satisfactorily, and little if any modification thereof is deemed necessary. The necessity for restricting the output and consequently the working force on account of limited appropriation, interferes somewhat with so complete a test of this system as might be desired, but even under existing conditions the modifications to be desired are in minor details only.

The hope held out in my last annual report, that by this time the work in the gun shop would be progressing as smoothly, economically, and expeditiously as could be expected, has, it is thought, been fulfilled. The shop seems in most excellent condition, both as to its plant and the organization of its personnel, and is capable of turning out a large number of guns yearly.

CARPENTER OR WOOD-WORKING SHOP.

The work of this shop has been considerably reduced during the year, and has resulted in a material reduction of the force employed. Nevertheless, the work on patterns for machining and heavy castings for the

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gun shops, the repairs of wooden 6-pounder and 12-pou
riages, the construction of patterns and models for issu
and preparing for transportation of ordnance and ordnai
the necessary work in connection with electric-plant con
repairs of public buildings have all combined to keep the s
of efficiency. The work of this shop includes the prepara
issue of considerable quantities of paint.

MACHINE, FINISHING, AND HARNESS SHOPS.

The cessation of work in the foundry has made a great diff
new work of the shops, but all necessary construction and
required by the gun factory has been well done, and the ca
work has been satisfactorily completed, as has all necessa
finishing large castings furnished by the contractor. A
invited to the large number of steel projectiles awaiting t
of a satisfactory paint before banding and finishing.

IS OF 16 INCH
ENAL, U.S.A

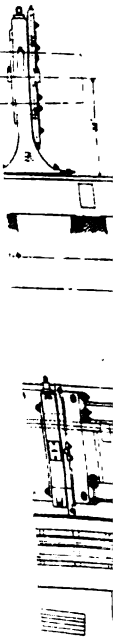
FOUNDRY.

The foundry was closed in January, the casting of 12-inch ir
iles being finished, and the flasks, patterns, etc., were tran
the Watertown Arsenal, in compliance with instructions of
of Ordnance.

ISAAC ARNO
Major, Ordnance Department, U. S. Army, Comm

(Plates Nos. 1 to 6 only are published.)

(1924)



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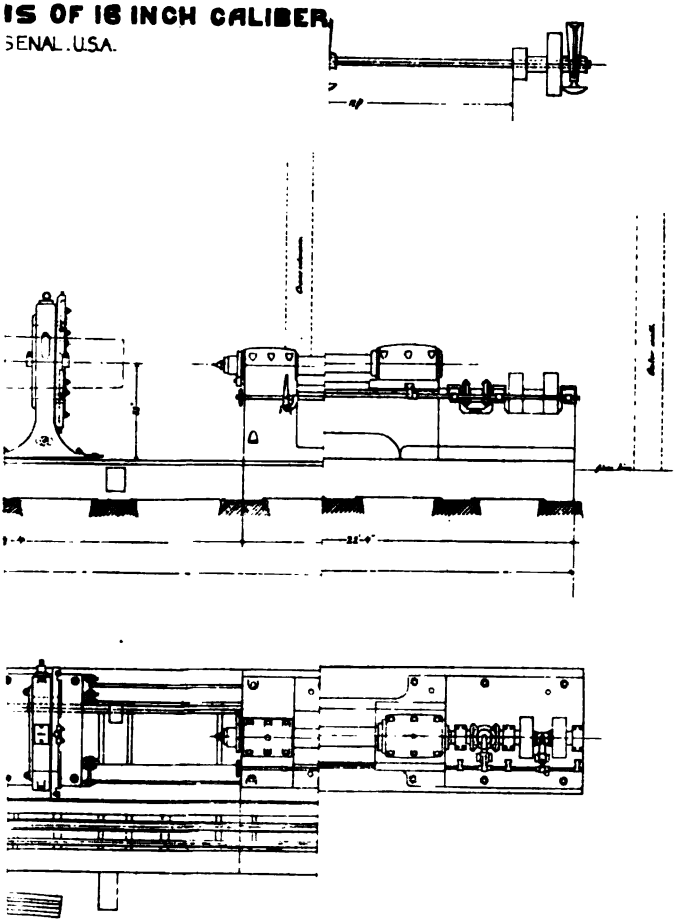

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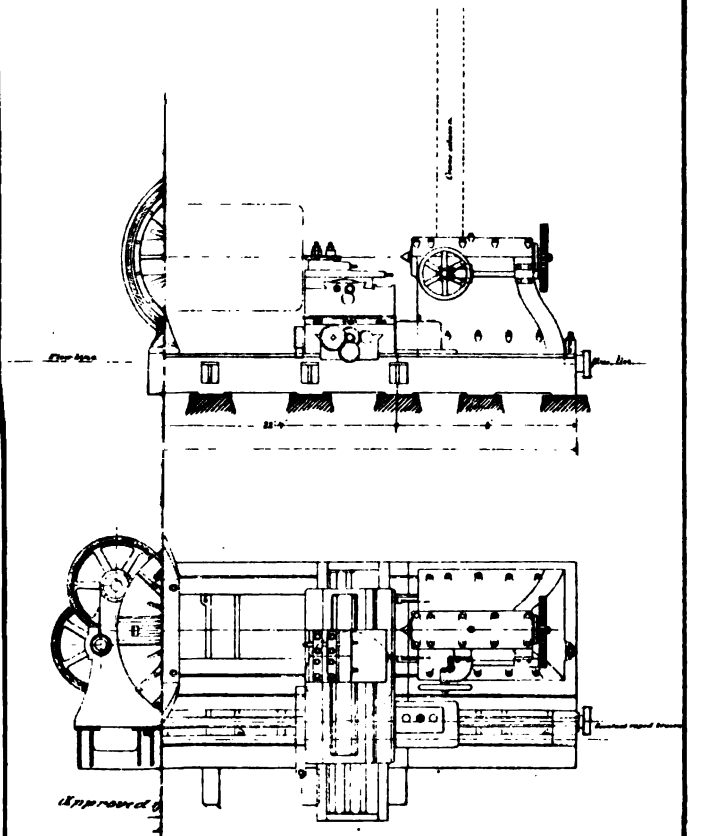
PLATE II.



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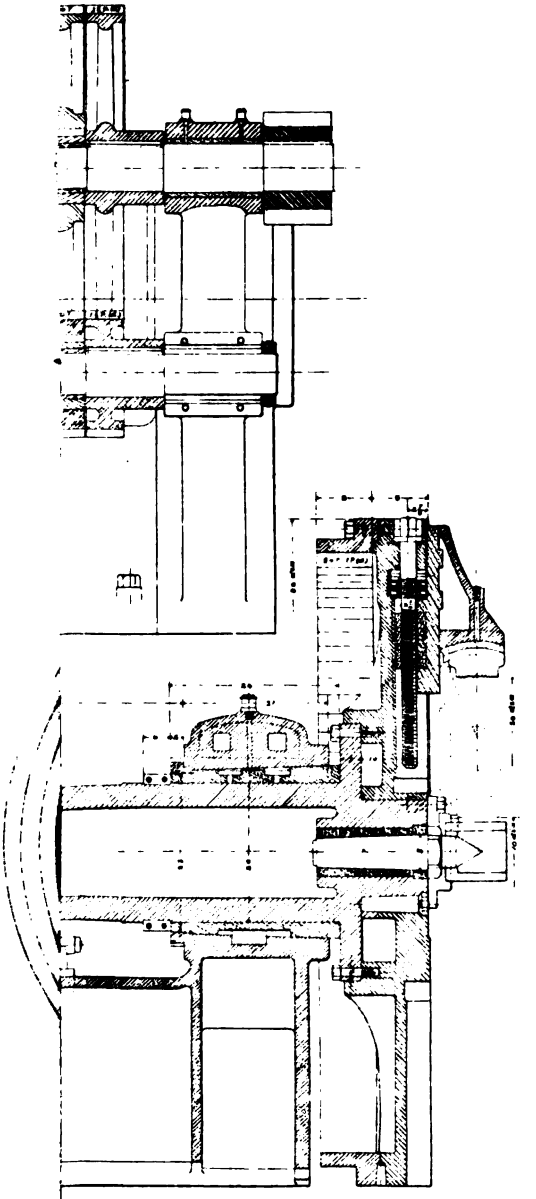

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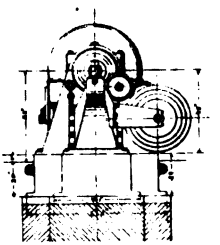

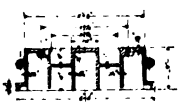

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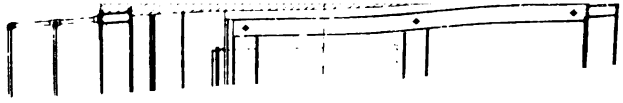

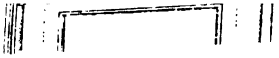

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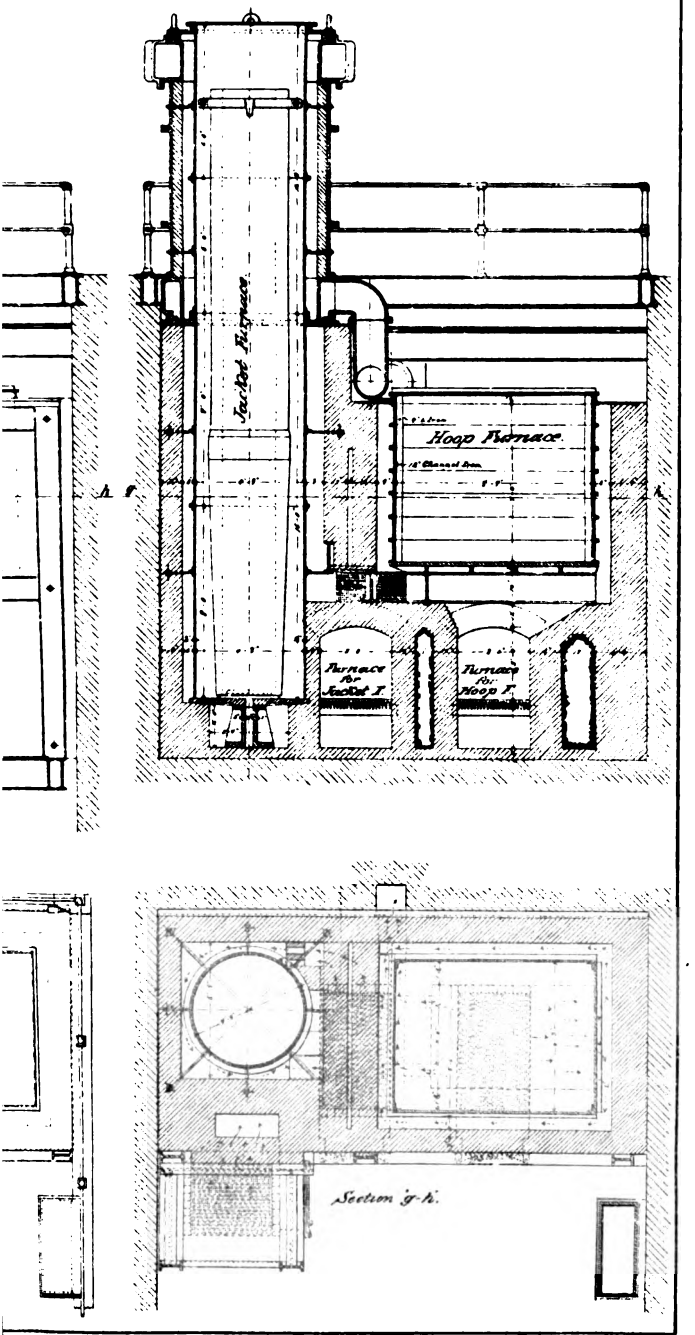

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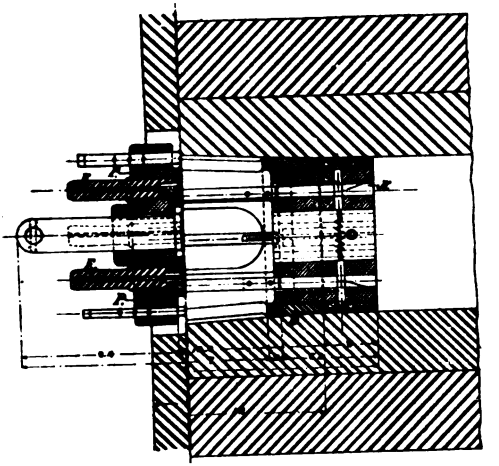
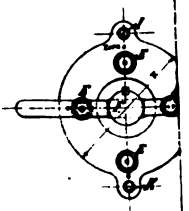
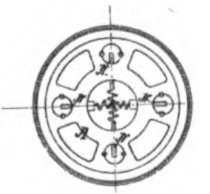
PLATE VI.





End view



End view.

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APPENDIX 15.

ANNUAL REPORT OF THE PRINCIPAL OPERATIONS AT THE WATERTOWN ARSENAL.

(1 plate.)

The principal operations at this arsenal during the fiscal year ending June 30, 1894, have been as follows:

In the enlargement and improvement of the gun-carriage plant, by the erection of new shops, the enlargement and alteration of old shops and storehouses, and the purchase, erection, and manufacture of new and improved machine tools.

The following machine tools, in addition to those mentioned in the reports of the preceding year, have been set up and are in operation:

Machine tools purchased during the fiscal year ending June 30, 1894.

MACHINE SHOP.

1 vertical boring and turning mill, 16 feet to 25 feet	$12,300
1 planer, 8 by 6 by 20 feet	7,500
1 planer, 4 by 4 by 24 feet	3,700
1 planer, 32 by 32 inches by 12 feet	1,110
1 four-spindle multiple drill	1,600
1 cold-saw cutting-off machine, No. 3	1,250
1 horizontal boring and drilling machine, 66 inches	2,400
1 bolt cutter, 3 inch	622
1 engine lathe, 10 inch	133
3 engine lathes, 14 inch	888
4 engine lathes, 16 inch	1,660
3 engine lathes, 24 inch	2,280
1 upright steam hammer, 1,100 pounds	1,194

SETTING-UP SHOP.

1 twenty-gross-ton double-trolley overhead traveling crane, 77 feet 3 inches span, under contract for delivery	$5,960

MACHINE SHOP.

1 double horizontal boring machine, manufactured at this arsenal	$2,500

In accordance with the approved plans of the Chief of Ordnance, work has progressed during the fiscal year in the enlargement and improvement of old shops and storehouses, and in the building of new shops, as follows:

The foundry has been completed by the removal of the 16-foot boring mill to the south wing of the machine shop and by lengthening the furnace room, on the south side of the building proper, so as to permit the erection of a larger core oven than the one first built—one of sufficient capacity to take in loam cores 18 feet 9 inches wide by 20 feet deep in size, for the lower roller paths for gun-lift and 12-inch barbette

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carriages. This addition also furnishes storage bins for fire clay, fir sand, etc.

By the use of the two cupolas and the air furnace at the same tim we can readily make castings of 30 tons weight, which are as large a will probably ever be required.

Under recent orders the discontinuance of the foundry (at least tem porarily) and the transfer of all patterns, flasks, etc., from the Water vliet Arsenal to this arsenal, leaves the Watertown Arsenal foundry th only one in the Department, I believe, capable of making castings o any size.

During the year the foundry has made all of the castings of bronz and iron required in the manufacture of 8-inch, 10-inch, and 12-inc barbette carriages; alterations of 15-inch and 8-inch converted rifl carriages; platform plates at Sandy Hook; the 8-inch, 10-inch, and 12 inch cast-iron projectiles for experimental purposes at Sandy Hook an for issue to the service, as well as small quantities of 3.2-inch and 3-inc projectiles.

The possession of the best testing machine in the country, with it adjunct, a chemical laboratory, enables us to keep close track of th qualities of the metals bought for these castings and of the resultin castings. The result is a minimum of loss in castings and consequently in the expense attending these castings. We are also absolutely sure of the soundness of the castings, for it is obviously not to our inter est to turn out completed products defective in any respect.

The special mixtures of irons required for castings of various kind and shapes can only be gained from experience. Different mixture differ in the amount of contraction in casting and in the grain, as wel as in strength and density. Having acquired this experience in the foundry, it would seem to be of public interest to keep it up and improve upon it. It should not be forgotten that the experiments of Rodman, an ordnance officer, on metals for guns brought the tensile strength of American cast iron from less than 15,000 pounds per square inch to 30,000 pounds per square inch and more.

The alterations in the machine shop have been completed, viz: The south wing fitted up as a one-story structure for the large boring mills, planers, and other large tools. The pattern room has been removed to the foundry extension from the second story of the north wing, thus opening up that entire story to small tools, and affording ample space for all probable additions to these. A new tool room has been fitted up on that story, with an elevator for tools to the first story, and the fore man's office removed to the center of the lower floors. A large arch has been constructed between the two wings of the machine shop, and connection made by rails and turntables from one end of the north wing to the far end of the other wing, entirely through the shop. Space has been left in the south wing adjoining the present engine room for an additional engine room when required.

It is proposed in the near future to reset the main battery of boilers perpendicular to their present setting, construct coal bins with con nections to the Fitchburg Railroad and to the boiler room.

In the foundry extension machine shop are located some of the larg est planers, boring mills, etc., among them a double horizontal boring mill of our own design and manufacture for boring the two hydraulic cylinders of a gun carriage at the same time; such a tool was not in the market.

The new erecting shop has been completed and in use for several months. At present one end of it suffices for setting up purposes,

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while the other end, with its railroad connection with the Fitch
Railroad tracks, affords space and facilities for the storage and
ment of completed carriages.

There are 3 20-ton hand traveling cranes in the machine shops
erecting shop, all capable of being converted into electric cranes
the work on hand justifies the expense. In our estimates for this
is embraced an item for and electric plant of sufficient capacity,
believed, to run these cranes, such electric machine tools as ma
desired, and to light the shops and post. It is believed that eco
would justify the erection of this plant as early as possible. In
short days of winter the light from gas is insufficient for accurate
a good part of the time, and the gain in this respect alone woul
several years, counterbalance the expenditure.

It was necessary, and it is still necessary in a less degree, t
cautious in the selection of our large tools, for the ultimate for
depressing carriage to be adopted and made here was not dec
upon. But the large tools, and the small tools for that matter
adapted to almost any class of work, and it is believed there is no
tern of gun carriage, at home or abroad, that can not be manufact
in the Watertown Arsenal shops.

It would be safe to go ahead now and complete the purchase o
tools necessary to equip the plant, and an estimate has been ma
that end.

The blacksmith shop is rapidly becoming an important part of
carriage factory. There are many steel forgings of various sh
some quite large, say several hundred pounds in weight, some s
but all are required to be uniform in texture and absolutely sou
every respect. Our experience in purchasing steel forgings to s
did not warrant a continuance of that plan. They were very co
many pieces developed defects in the working, and the times of deli
delayed our work; to replace defective pieces in each lot delay
still more.

Our largest steam hammer is of two tons capacity, and capab
forging most of the steel pieces required. By purchasing the
mered open-hearth billets of the required physical qualities fro
steel-makers we have not only been enabled to get better forging
the greater care we have taken with them, but to make the forgin
needed and at less than half the price paid formerly.

Sufficient experience has been had to justify us in entering
steel forging upon a larger scale. It is proposed to erect a 5-ton s
hammer which has sufficient power to reach effectively the interi
the largest steel forging in any of the proposed gun carriages.
sidering the importance of sound steel forgings in gun carri
nothing should be left to chance in securing the best.

In all of the modern gun carriages are steel castings of large
and the top carriage is a complex affair. Many of these castings
been rejected for various defects, as for instance blowholes. It s
to be impossible in the present stage of the steel-casting indust
secure castings of large size; and although made after the same pat
yet of the same size. The shrinkage seems to vary with the he
the molten metal. This difficulty will doubtless be remedied in
and gun carriages may be made with their parts interchangeable
similar parts in other carriages. It may not be essential that
large castings be interchangeable; at all events they are not i
carriages now being made.

The old storehouse opposite the machine shop has been converte

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a carpenter and pattern shop by removing its floors so as to make it a single-story building, and a wing has been added to its northwest corner for an engine room, foreman's office, and storage room, and the carpenter shop equipped with the most approved tools. Steam is brought to the engine by an underground conduit from the main battery of boilers at the machine shops. This conduit consists of an iron pipe encased in a nonconducting material, and inclosed in an interior and an exterior wooden box. The exterior box is coated inside and outside with coal tar. The depth of the top of the box is only 18 inches below the ground, yet when the snow last winter was covering the ground there were no indications of the steam pipe so close below.

All of the patterns for the 8-inch, 10-inch, and 12-inch B. L. barbette carriages, the 12-inch gun lift carriage, platform plates for Sandy Hook, and many smaller constructions have been during the year made in this shop. This shop has also had its full capacity employed in getting out mortar wagons, sling carts, gun lifts, gins, rammers and sponges, and other implements and equipments for the service, mounting and moving of the seacoast armament. As the guns and carriages grow in size and complication the implements and equipments also grow in size and complication. The gun lift has been adapted to the service of the 15-inch gun on the improved carriage, but it will not answer for mounting the new armament.

The transportation of large gun carriages involves great trouble and expense. It is possible to construct special cars that will carry these carriages by rail in pieces to their destination, but it is very desirable that they be transported with no more dismantling than necessary. A dock upon the Charles River within our grounds enables us to transfer to lighters drawing less than 12 feet gun carriages entire for transportation to points upon the Atlantic or Gulf coast. As our fortifications are upon exposed points and islands, with which there are no close railroad connections, the carriage, even if transported by rail from here, eventually has to be transferred to lighters. There may be no facilities at the end of the railroad lines to transfer heavy weights. It would seem to be desirable, therefore, in many instances, to ship from here by water. I have consequently estimated for a sufficient amount to build a railroad from the erecting shop to the wharf.

The improvements and changes in progress in the shops during the preceding year left over to this fiscal year a great part of the work of that year in the alteration of the 15-inch and 8-inch converted rifle carriages. But we were able to clear our hands of this left-over work and report completed, at the end of the year, 23 15-inch and 9 8-inch converted rifle carriages.

Of the new model 8-inch B. L. barbette carriage, 7 have been completed during the year (except a top carriage for one, which was rejected for defects). Two of these have been issued to the service, 1 each to West Point and Fort Monroe, and the remaining 5 carriages are in store awaiting orders for shipment.

Two 12-inch B. L. barbette carriages have been completed during the year. One of them was issued to the proving ground for test; the other remains in store subject to issue. The remaining two carriages of this kind under construction have been delayed in their completion by the failure of the Steel Casting Company to supply perfect castings. They will, however, be completed in the course of several months, possibly by September 30, 1894.

We have also in process of construction 3 12-inch gun-lift carriages. The construction of these carriages has also been delayed by

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nonreceipt of steel castings, but many of their parts are so advanced that if the steel castings to be received prove sound then completion is but a matter of several months' work.

We have also in course of construction 5 10-inch B. L. barbette carriages. The contract for the steel parts of these carriages has been let, and the entire lot will be completed during this fiscal year.

The designs of these carriages had to be worked out in all their details, patterns, models, etc., and improvements added as they were suggested during the process of construction. The machine tools capable of doing the work required on them had to be purchased and set up. The delay in their construction does not seem unreasonable.

One of the most important and most interesting departments of this arsenal is the testing department, with its adjunct, the chemical laboratory. It is only necessary here to speak of its work in connection with ordnance matters. Its operations entire are embraced in an annual report issued as a public document under authority of Congress.

For many years this machine has been employed to a great extent in determining the physical qualities of the metals used in gun construction, and its tests have done much to lead to improvements in these qualities. During the past year tests have been made for the Department upon material representing 8, 10, and 12 inch B. L. guns and 12-inch rifled mortars, steel for the .30-caliber repeating rifle, also upon steel and iron for gun carriages, and cast iron for the shot and shell being made here.

Work has also been done for various other Departments of the Government, as upon chains, shackles, and swivels for the Navy Department and light-house inspectors, and shot lines for the Life-Saving Service.

The class of investigative tests has comprised, among others, the test of an 8-inch steel rifle gun tube. The results of the tests as originally designed will be published in a "Note on the construction of ordnance." It is only necessary to say here that a close concurrence was found in these experimental results with the computed results based on formula for gun construction, as developed by Capt. R. Birnie, Ordnance Department.

Supplementary tests are to be made upon the same line of investigation, and upon completion of this series the results will be embodied, it is believed, in an additional "Note."

The annual report of tests of metals will contain an enumeration of the mixtures used in the arsenal foundries, brass and iron, the tensile strengths of the resulting metals, and their chemical analysis. Mechanical tests and analysis are also given of pig irons which have been used.

The high tensile strength uniformly displayed in the castings produced will render the information conveyed by these tests of great value in all cases where a superior grade of iron is required.

In conjunction with the exhibit of tested material at the World's Columbian Exposition at Chicago, some railroad-track experiments were carried out on the track of the Chicago, Burlington and Quincy Railroad. The experiments showed the behavior of different weights of rails on two different kinds of ballast, gravel, and cinder, under the weights of different classes of locomotives. Observations were made showing the total depression of the rails according to the weights and wheel bases of the locomotives, and the fiber stresses in the rails in different positions, with reference to the wheels and the supporting tires.

It is believed that this class of tests is of special importance in

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supplementing the tests made directly in the testing machine, and that the safety of the traveling public would be increased by more fully developing information of this character. Tests have been continued to determine the endurance of metals to repeated stresses in the form of rotating shafts, and specimen tests have been made of the metal after a large number of repeated loads have been received. Much interest is taken in these tests as well as in the direct practical determination of the stresses which are endured by material in actual service, because classes of tests form, as it were, a connecting link between the every day use of metals and the more comprehensive but somewhat abstract investigations of the laboratory.

About the close of the last fiscal year some phenomenal results were obtained with shafts rotated at temperatures above 400° F., when it was found that the metal endured from four to ten times the number of loads which it was capable of enduring when the metal was cold. Specimens of an annular form have been tested from these shafts which ran so long at a blue heat, and the tensile strength was found much higher than that possessed by specimens taken from the cold metal. The general drift of evidence furnished by ruptured specimens has for a long time tended to show that metals while loaded within a limit represented by what is commonly known as the elastic limit would endure a large number of repeated loadings before rupture, nevertheless that when rupture took place, although nominally under a stress not far from the elastic limit, yet there were strong reasons for believing that actually the stresses on the parts ruptured first passed through a state of resistance bearing some relation to the tensile strength of the metal; in other words, that while the elastic limit in a measure fixed the limit of stress which it would be safe to apply a large number of times, yet before rupture would occur the metal would first pass through the higher stresses between the elastic limit and the tensile strength of the metal.

At a blue heat the elastic limit is lower than at atmospheric temperatures, yet the tensile strength is much greater at this elevated temperature. The fact that certain of the specimens from the shafts showed higher final strength is strong evidence that when rupture occurs the metal is then at its maximum strength, or has been at some time prior to the instant of rupture. This being the case, we should expect the development of internal strains might explain the difference between the apparent and the real strength of the metal.

Tests will be continued and efforts made to detect *a priori* evidence of deterioration and impending rupture in metals. Through tests of this class, it is hoped the relation of chemical composition and mechanical treatment in steels may be better understood.

It is thought that opportunity will be found during the coming fiscal year to resume the subject of tempering of steel bars. A systematic investigation of the possible combinations of physical properties in steels of different percentages of carbon and other elements will greatly facilitate future work when tempered metal is employed.

A drop-testing machine, for which an item has been embraced in my annual estimate, is needed to supplement the work of the testing machine. The failures of material in services generally, and at all times in ordnance constructions, occur under the effect of a shock or suddenly applied load. The transmission of suddenly applied loads in bars, or in parts of finished structures when the loads are confined to the elastic limits, and also when those limits are exceeded, are

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important subjects of investigation and of especial interest to ordnance constructors. (I also inclose description of a barbette carriage for 12-inch B. L. rifle with sixteen tracings (see Appendix 16). Description of a double horizontal boring machine built at Watertown Arsenal, with seven tracings showing details of machine (see Appendix 17). One tracing showing modified Piper gin.

Very respectfully, your obedient servant,

J. W. REILLY,
Major, Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

WATERTOWN ARSENAL.
August 29, 1894.

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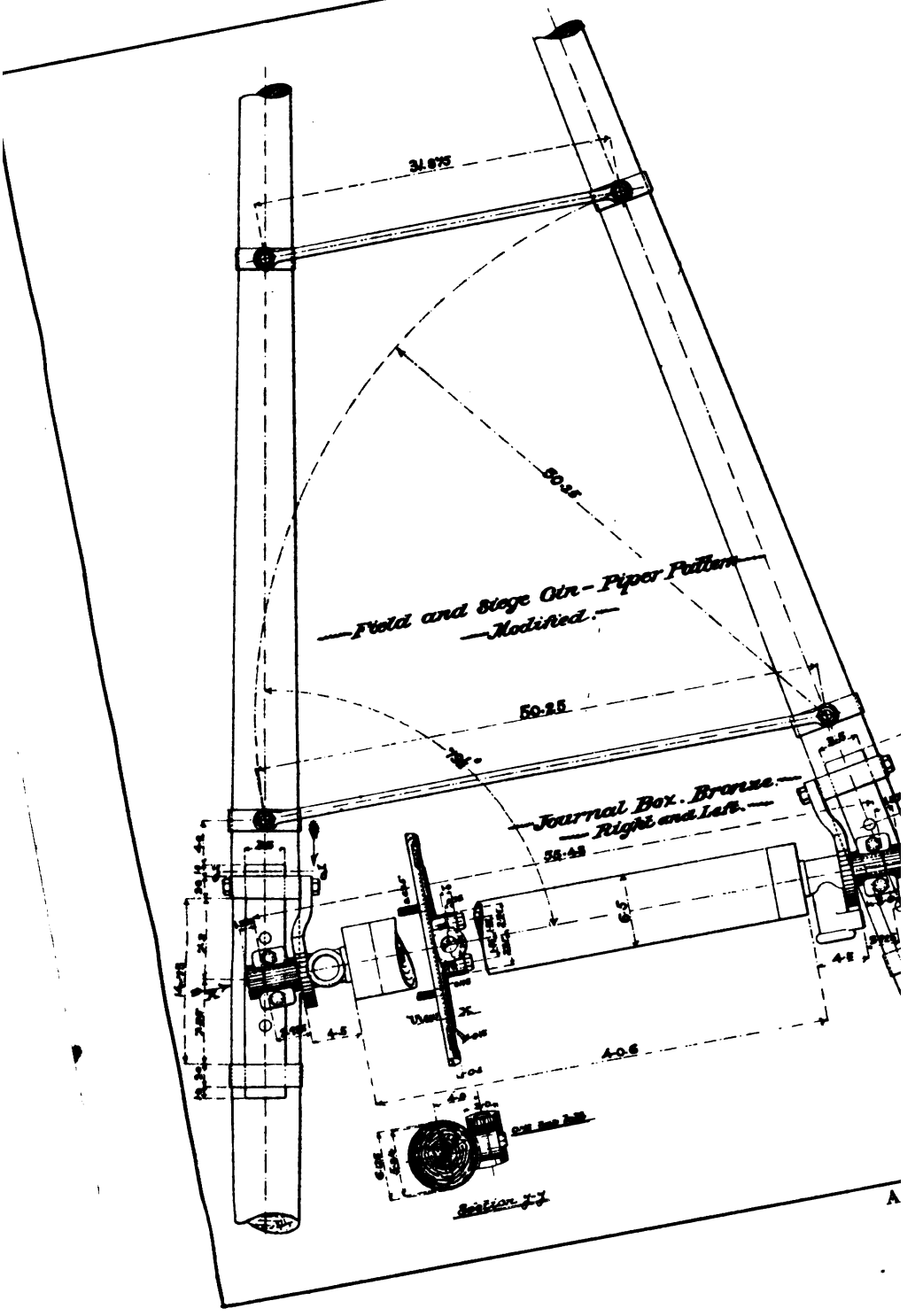

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APPENDIX 16.

DESCRIPTION OF BARBETTE CARRIAGE FOR 12-INCH B. L. RIFLE.

(16 plates.)

BARBETTE CARRIAGE.

The carriage consists of the following principal parts: (1) The top carriage. Plate II. (2) The chassis and upper roller path. Plates III and IV. (3) The lower roller path, together with the devices for checking recoil, elevating and traversing the gun, and lifting the projectile. Plate V *et seq.*

The lower roller path or bedplate is bolted to the platform. Upon it rests a live roller ring of forged steel rollers supporting the upper roller path and chassis. The top carriage rests on the latter.

THE TOP CARRIAGE.

(Plate II.)

This is mainly in one piece of cast steel, containing the trunnion beds and hydraulic cylinders. The cheeks are joined by a transom, dished at the rear to permit the elevation of the gun. The carriage rests on 18 recoil rollers of forged steel, placed in pockets formed in the chassis. The trunnions of the gun are retained in their beds by cap squares fitted to undercut recesses in the top carriage and bolted down.

The hydraulic cylinders are machined on the inside and receive the apparatus for checking recoil. Throttling bars, so called, of uniform width and varying depth (shown in detail in Plate VIII) are bolted to opposite interior rectilinear elements of the cylinder, the piston heads being slotted to travel over them. The change in profile of the throttling bars regulates the passage of the neutral oil, used in the cylinders, through the slots in the piston head according to the force of recoil. An equalizing pipe connects the ends of the hydraulic cylinders, and filling and emptying holes are provided at rear and front of the cylinders. The convex surfaces of the piston heads are covered with bronze and the trunnion beds are similarly lined.

The cylinders are threaded at the rear to receive steel cylinder heads with recesses into which fit, with slight clearance, the prolongations of the piston rods, for checking the shock when the gun returns in battery after firing. The front ends of the cylinders are closed by stuffing boxes, consisting of bushings, glands, and followers, through which the pistons pass. The space for packing is filled with hemp, against which the gland forces the follower to prevent leakage of the neutral oil in the cylinders.

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The piston rods are attached, at their forward ends, to projections cast on the front part of the chassis. These projections serve as part supports to a gun shield which may be bolted to the chassis.

The lateral bearing surfaces of the top carriage upon the chassis are lined with bronze strips, to prevent burnishing the steel. The outer edges inclose the edges of the chassis rails, to prevent the top carriage from rising when the gun is fired.

THE CHASSIS AND UPPER ROLLER PATH.

(Plates III and IV.)

These are of cast steel. The chassis rails are inclined at an angle of 4°, with the horizontal sufficient to insure the easy return of the gun in battery, by the action of gravity, after firing. The sides are accurately fitted between lugs on the upper roller path and are securely bolted to the latter. The front end is also hooked over a projection on the upper roller path. Four forged-steel clips are bolted to the outside surface of the upper roller path. A lip on these engages under the geared flange on the lower path to reduce jump in firing and returning in battery. A dust guard, made in four sections, is bolted between the clips and protects the live roller ring. The carriage is provided with rubber buffers at rear of chassis, in case the recoil is not taken up in the designed 48 inches.

THE LOWER ROLLER PATH OR BEDPLATE.

(Plate V.)

This is in one piece of cast iron, fastened to the platform or bed by sixteen 2-inch bolts. It has a pintle cylinder, over which fits the pintle bearing of the upper roller path. A spiral oil groove is cut in the outside of the pintle cylinder. A live roller ring of 24 conical forged-steel rollers rests upon the bedplate, and upon this ring the remainder of the system is supported and traversed. These rollers rest on an accurately planed surface, and are held at equal intervals from each other between two wrought-iron distance rings, which are slotted to receive trunnions turned on the ends of the rollers. The rings are held concentric with each other by cast-iron separators, fastened to the rings by wrought-iron bolts. Flanges on the inner ends of the rollers, extending above and below the respective roller paths, retain the system concentric with the pintle. The upper flange of the roller path is geared all around to receive the pinion used in traversing. A graduated training circle is attached to the lower roller path and is marked to degrees and half degrees, and, by means of a graduated pointer bolted to the left front clip, may be read to two minutes.

THE ELEVATING MECHANISM.

(Plate VII.)

This consists of a shaft, supported in bearings attached to right side of chassis. The shaft is squared for a distance, to the rear from its bearing, equal to the length of recoil. It is actuated by two handwheels and a shaft at the front of the carriage through the medium of spiral and mitered gearing. The miter drives an upright shaft, working in bearings attached to the top carriage. At the end of this shaft

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is attached a worm, actuating through a worm wheel a pinion which operates the elevating arc. The elevating arc is bolted to the gun. The worm wheel has a friction clamp, which permits motion to the gear during recoil without strain on the elevating mechanism.

The gun can be elevated from either side of the carriage and from $-7°$ to $+15°$. Degrees of elevation are noted on the elevation indicator. This consists of a bronze rack attached to the end of left trunnion of the gun. The rack actuates a bronze pinion on a stud attached to the cap square. A pointer attached to the pinion indicates the degrees on a graduated bronze arc attached to the top carriage. A spring catch permits the easy removal of the pointer, to prevent injury, during firing. An adjustable counterweight to the pointer controls the contact between the teeth of the rack and the pinion and takes up the back lash.

The arc is graduated to represent degrees and half degrees, and by means of a graduation on the pointer can be read to 2 minutes. On the lower edge of the graduated arc, space has been left for range graduation.

Plates attached to either side of the carriage, above the handwheels for elevating, indicate the directions for elevating and depressing.

TRAVERSING GEAR.

(Plate IX.)

Traversing is effected by means of a shaft having a crank at each end. To the middle of this shaft is attached a worm. This engages in a worm wheel on a vertical shaft, having at its lower end a pinion which meshes in the rack cut on the lower roller path. The piece can be traversed through the entire circumference.

SHOT HOIST.

(Plate XI.)

Hoisting of the shot is effected by means of blocks attached to a crane. The crane is held by two lugs on the left side of chassis. A manila rope passes over the guide pulleys of the crane to the drum, which is driven by a spur gear and pinion. A ratchet wheel and pawl are provided for "holding" the shot at any time during the hoist.

CHASSIS SIGHT.

Provision is made at the rear end of the right chassis for the chassi sight.

A platform attached to the chassis affords standing room for operating breech mechanism, loading, and cleaning. A sliding plate in the platform is attached by rods to the top carriage and moves with the top carriage from and to battery.

The total weight of the carriage is 112,804 pounds, or about 50 tons, distributed as follows:

	Pounds
Top carriage	17,590
Chassis and upper roller path	46,670
Lower roller path	34,120
Platform, crane, and other parts	14,424

Weight of the moving parts of carriage, about 34 tons, and, including the gun, 86 tons.

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LIST OF DRAWINGS.

Plate I. General drawing.
II. Top carriage.
III. Chassis; standard for chassis sight; crane bracket.
IV. Upper roller path; dust guard; azimuth indicator.
V. Lower roller path.
VI. Distance rings; conical rollers.
VII. Elevating apparatus.
VIII. Recoil brake; counter-recoil buffer; stuffing box.
IX. Traversing apparatus.
X. Piston rods, heads and nuts; recoil rollers; roller journals; guide hooks; buffers and buffer brackets.
XI. Shot hoist (hoisting apparatus).
XII. Loading platform; platform for chassis sight.
XIII. Sliding platform and connections.
XIV. Elevation indicator.
XV. Bolt list.
XVI. Nomenclature, principal dimensions and weights, bill of material.

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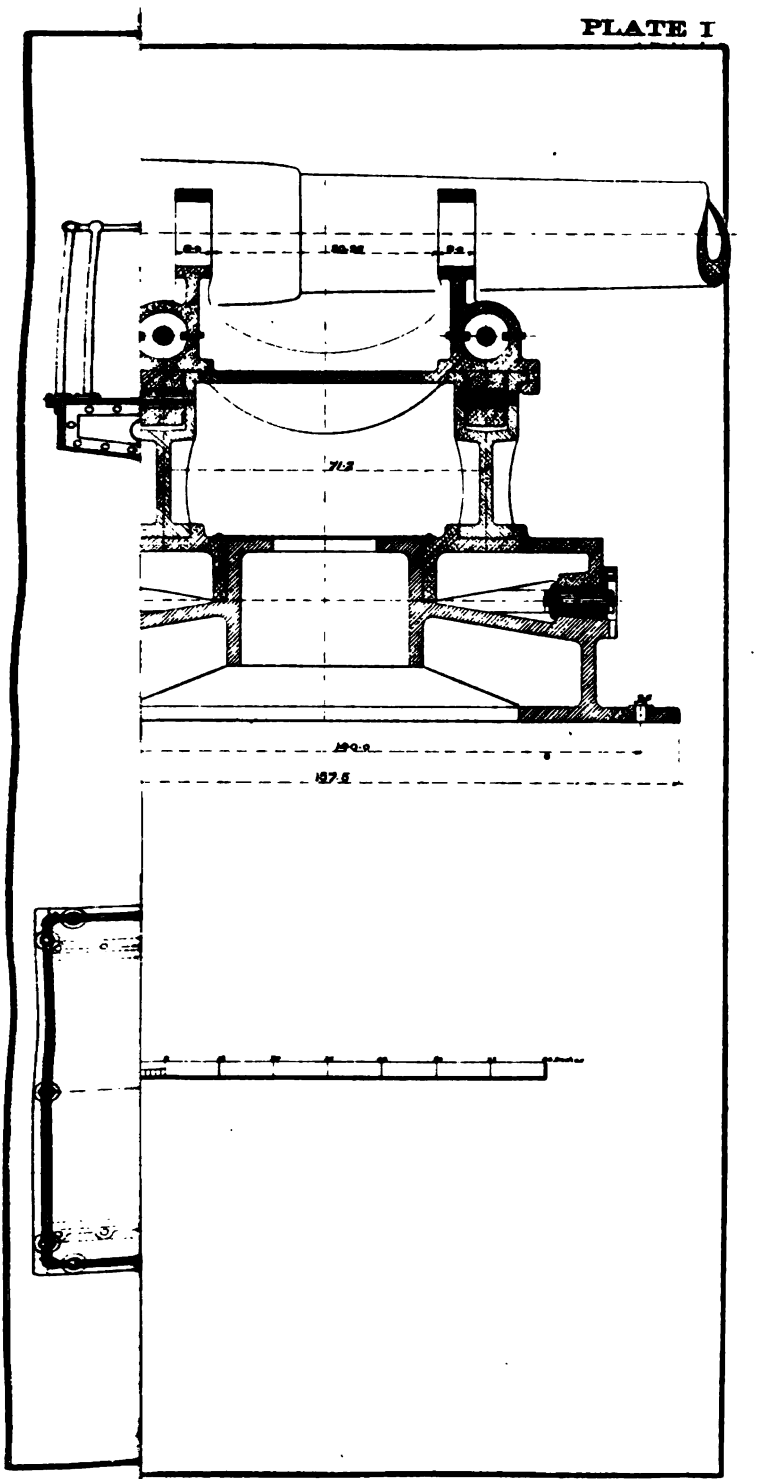
PLATE I



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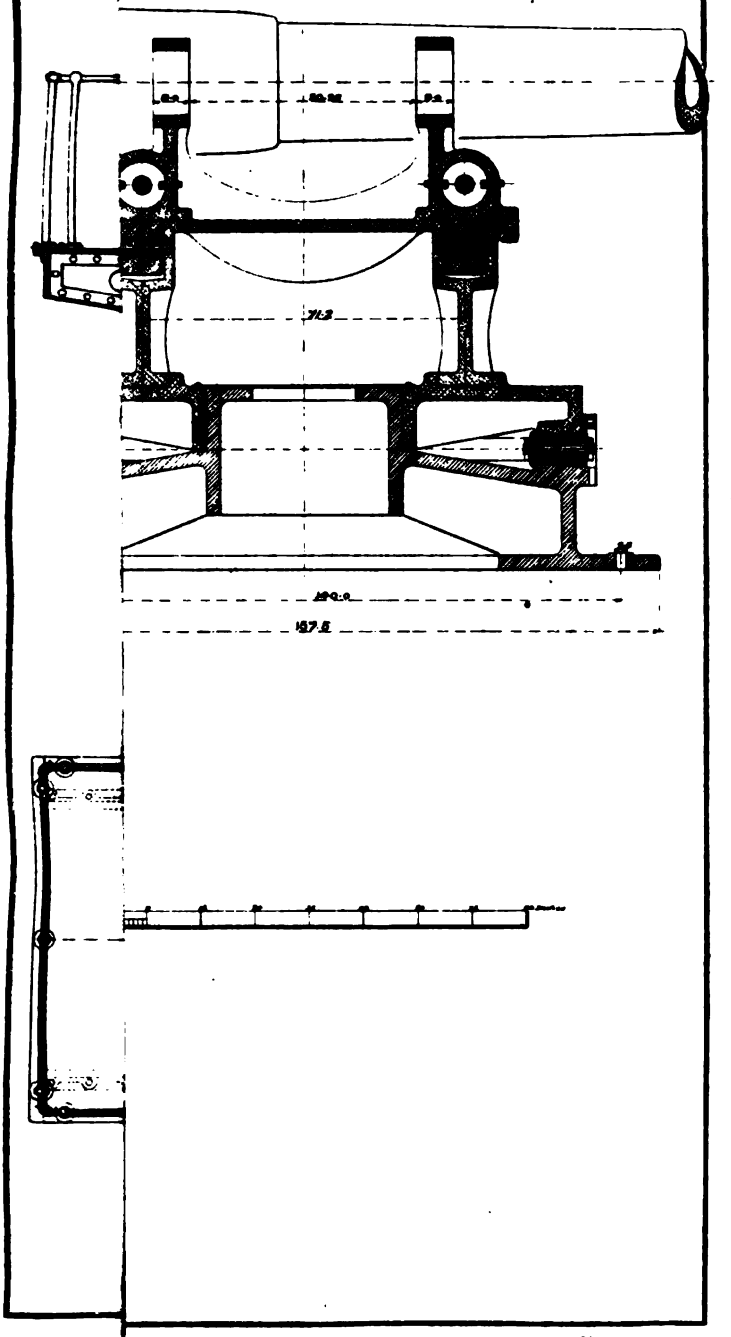

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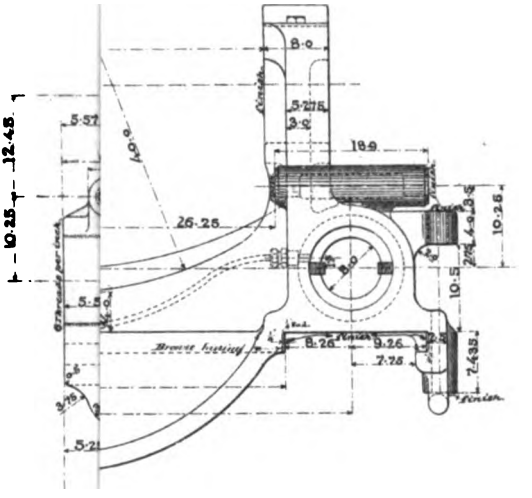
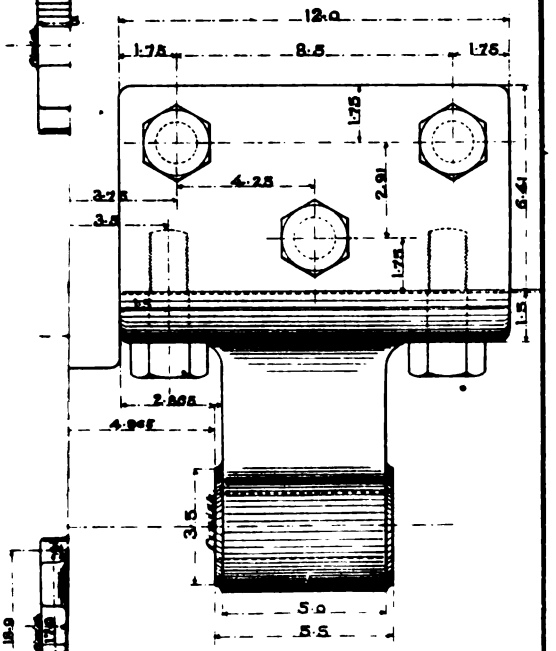


for Elevating Shaft.
This - a set—Cast Steel:—



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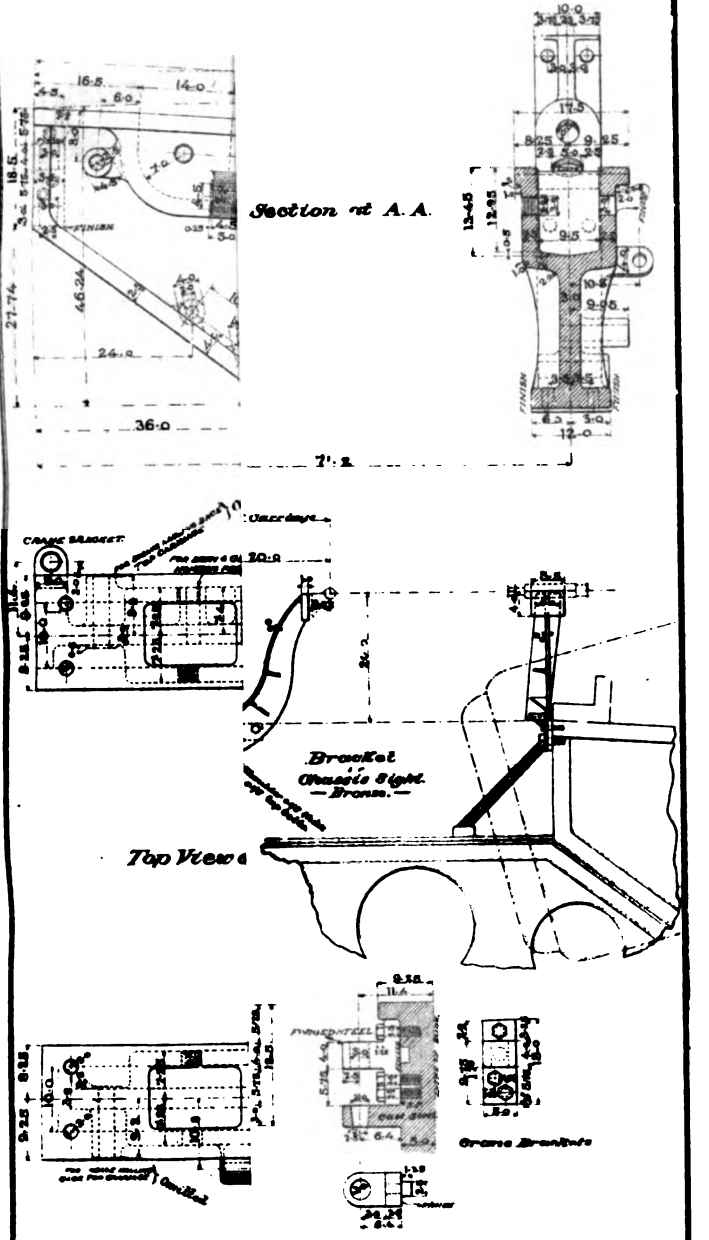

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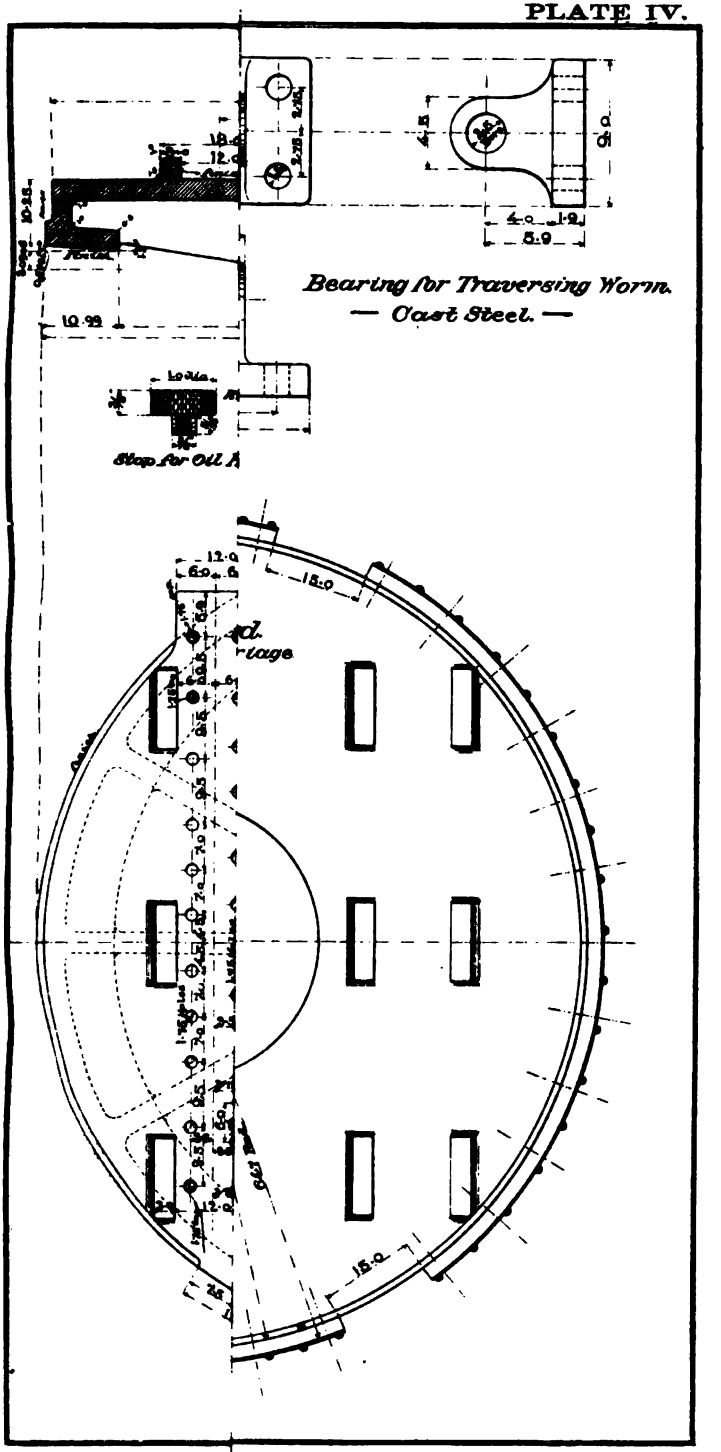

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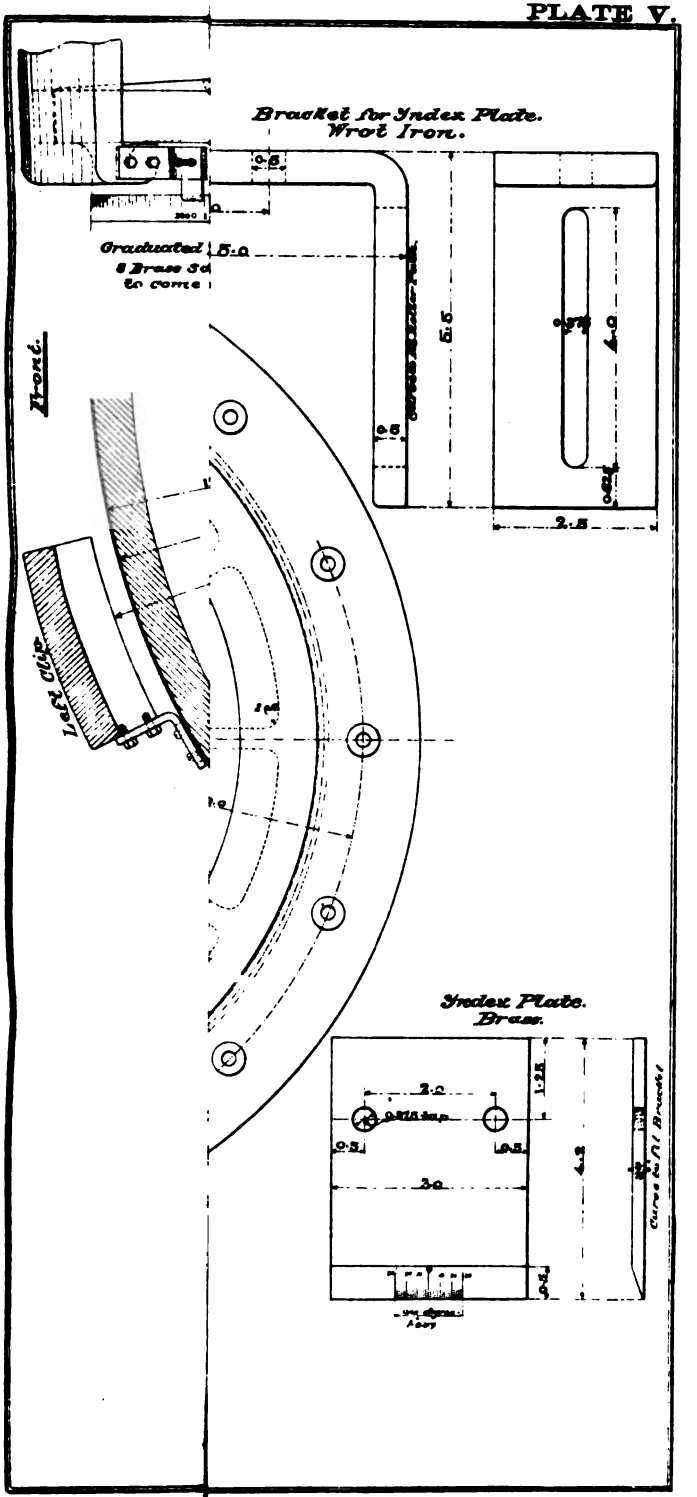

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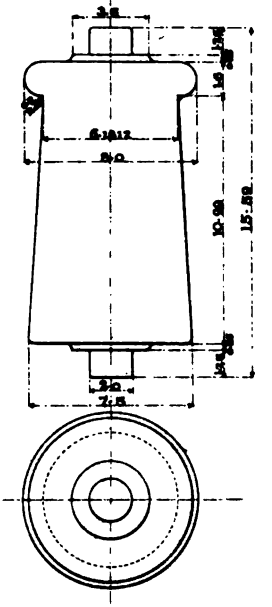
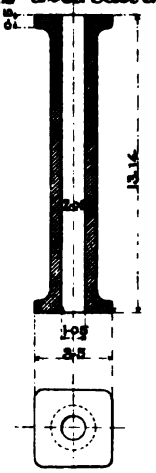
Conical Rollers.
24- a Set. Forged Steel.
— FINISH ALL OVER —



Braces.
12- a Set- Cast Iron.-



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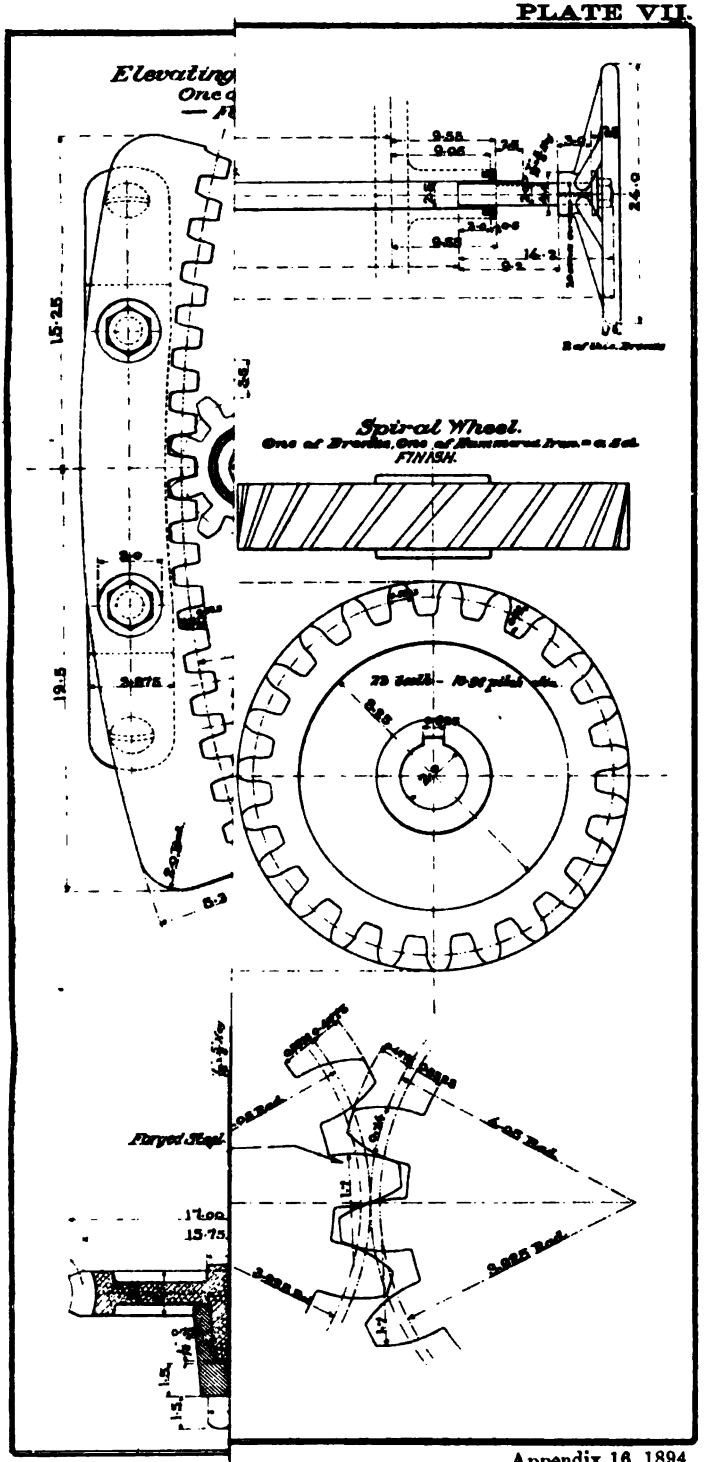

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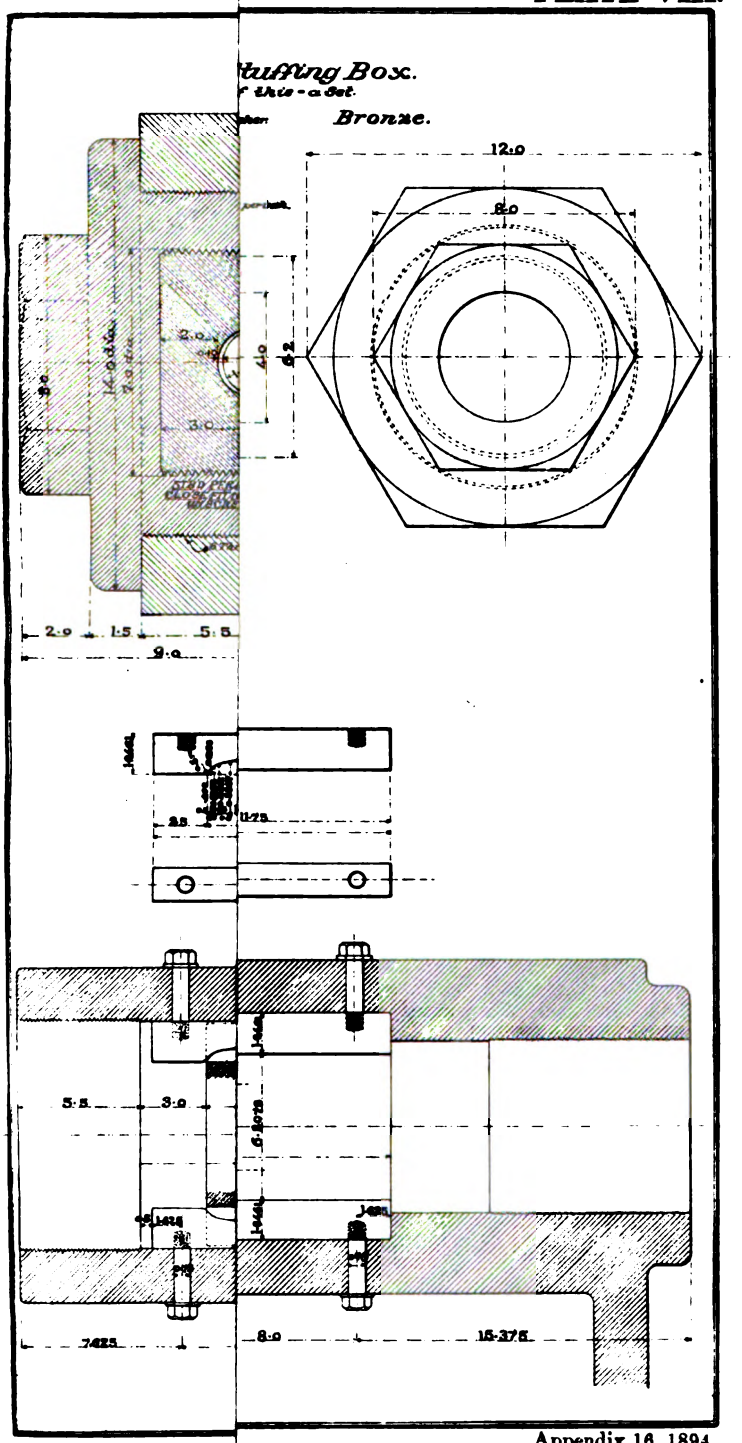

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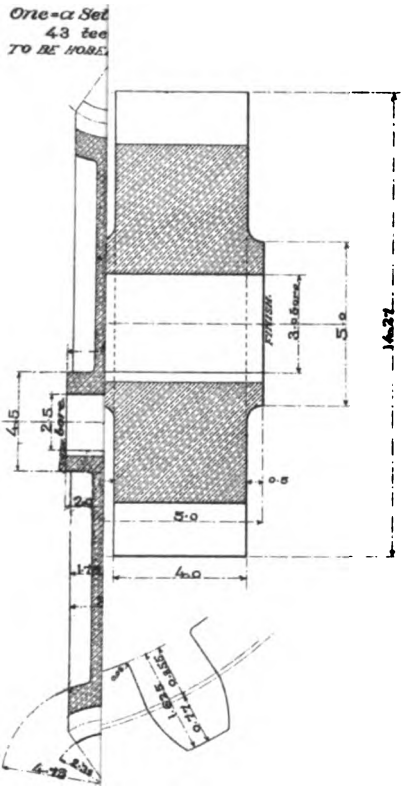

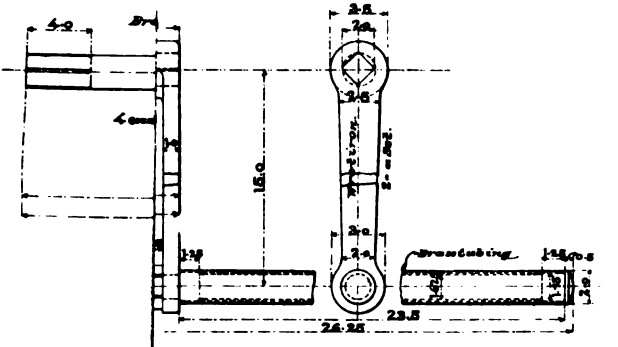

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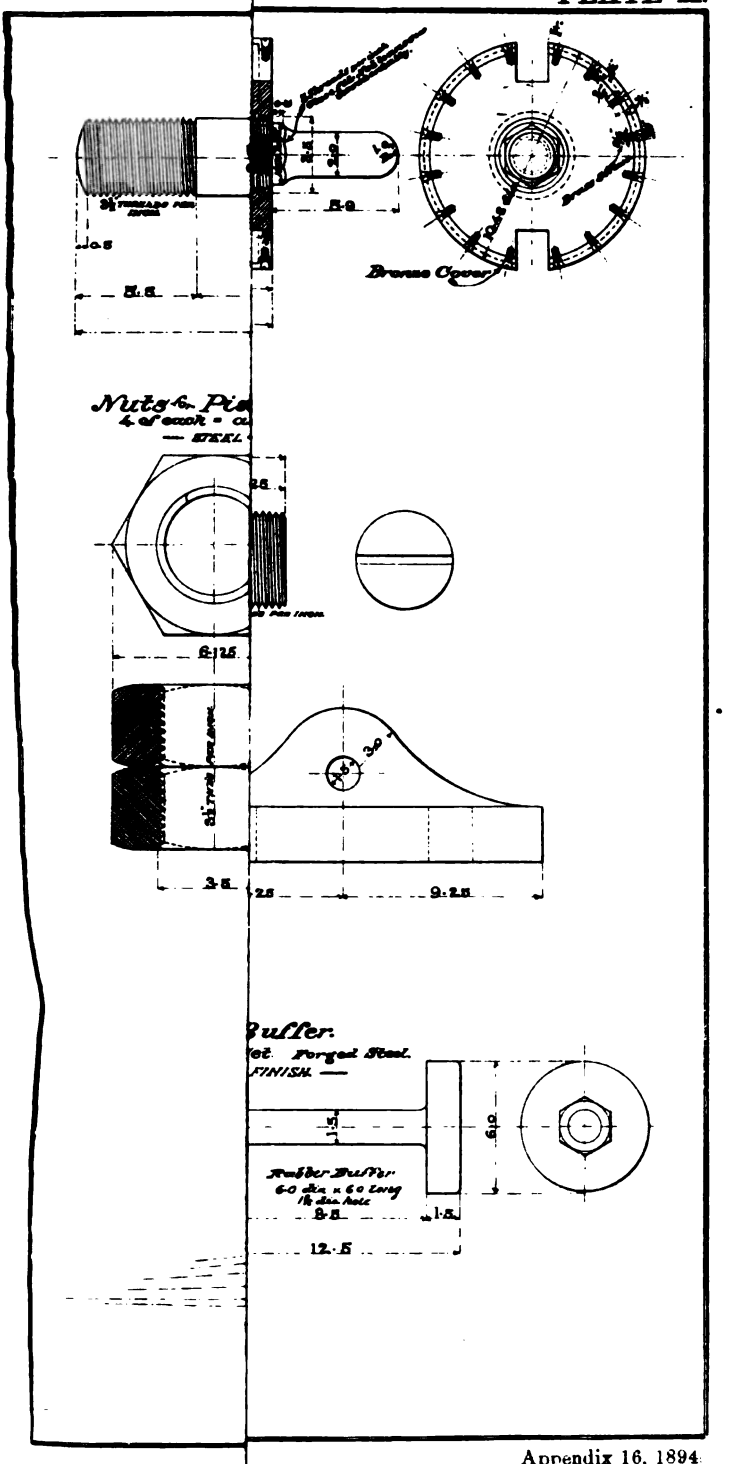

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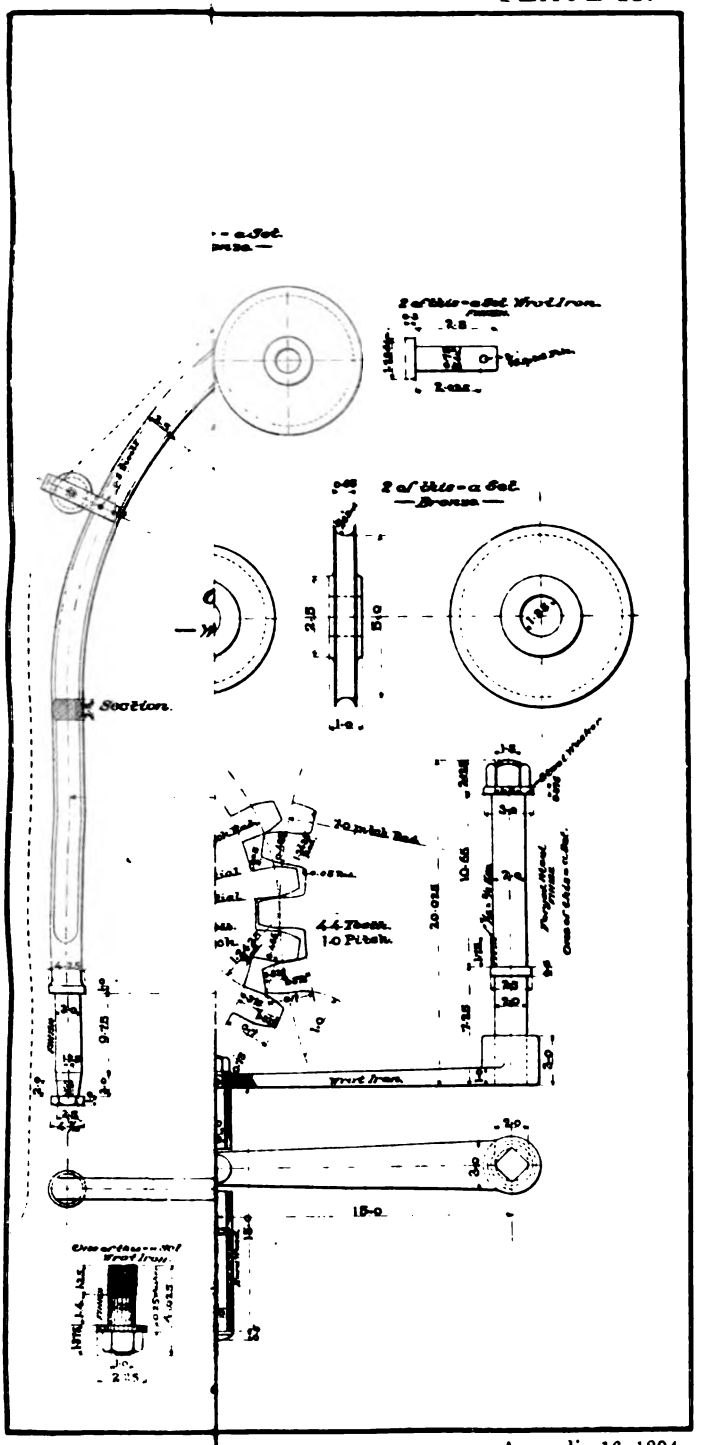

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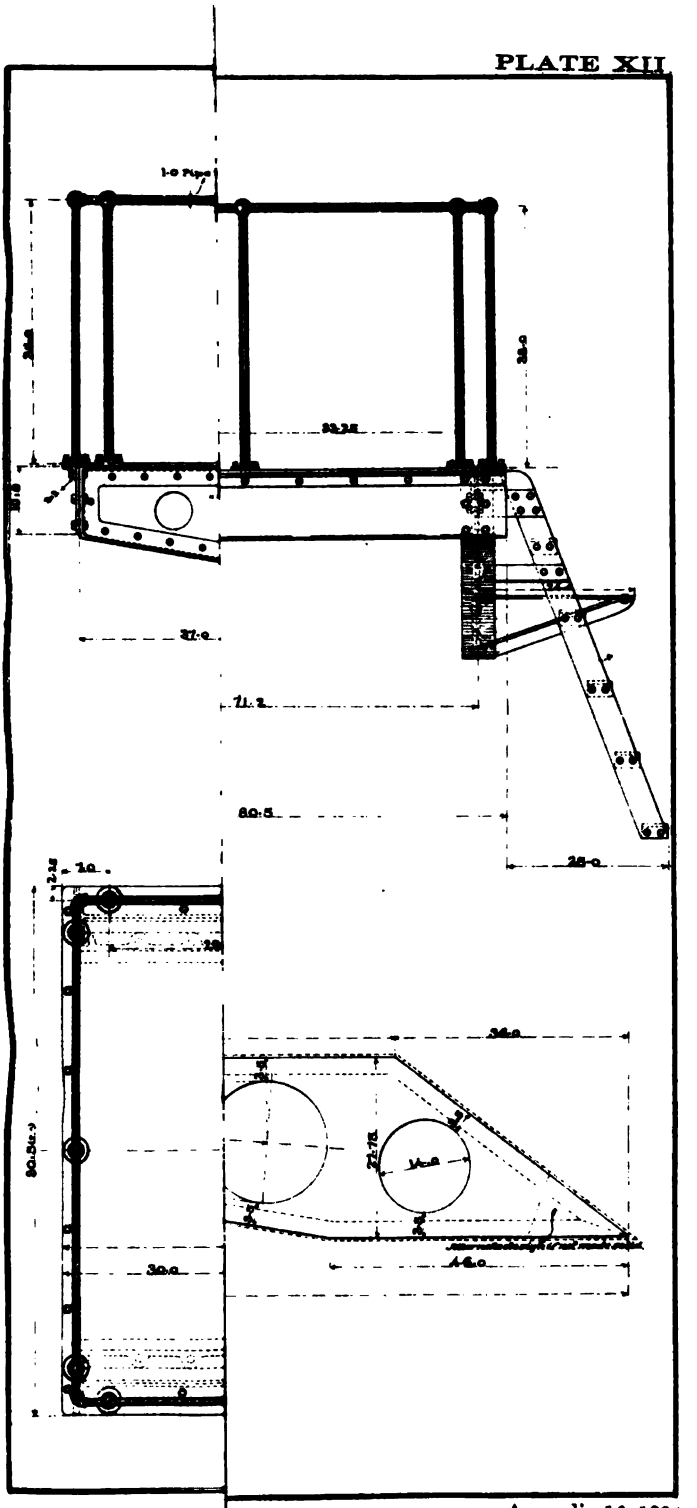
PLATE XII



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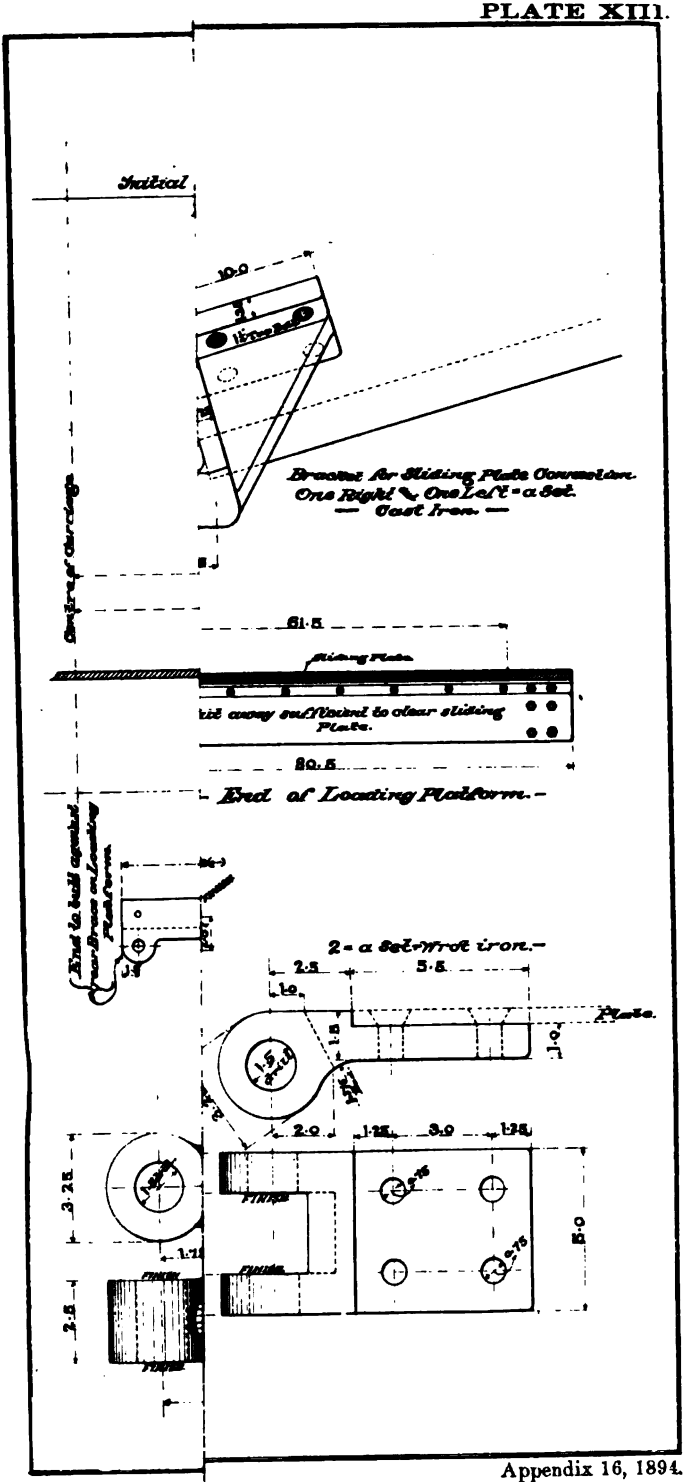

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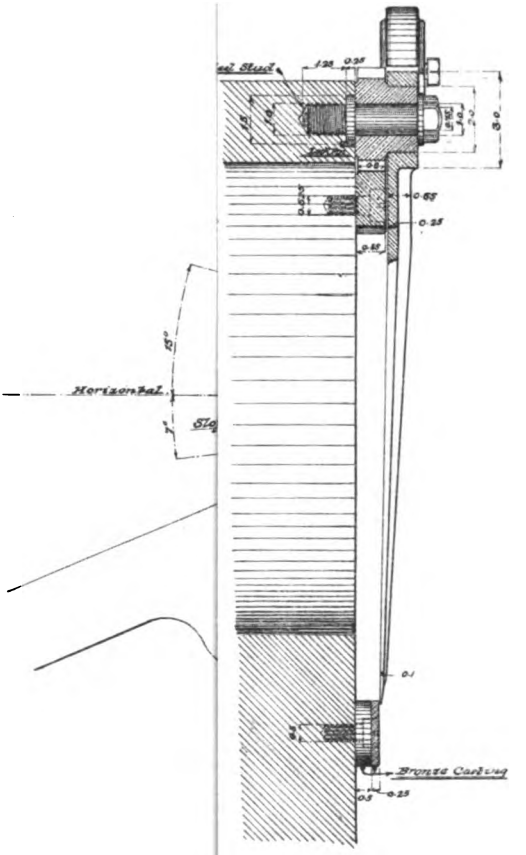

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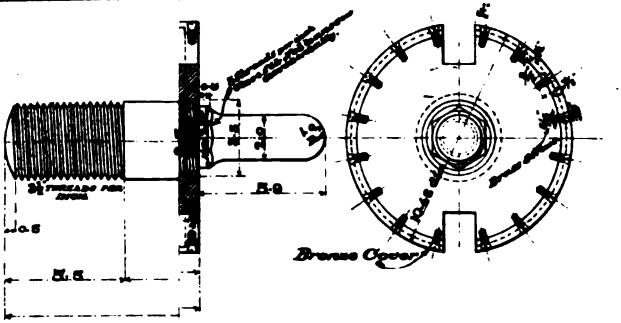

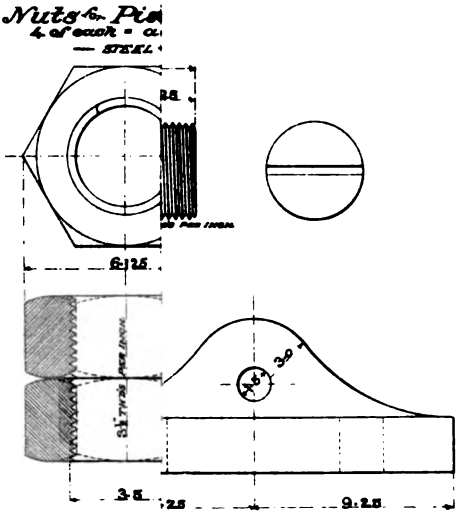

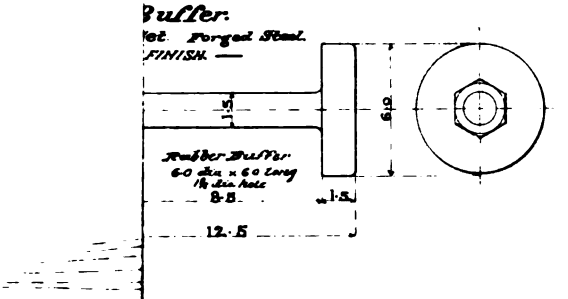

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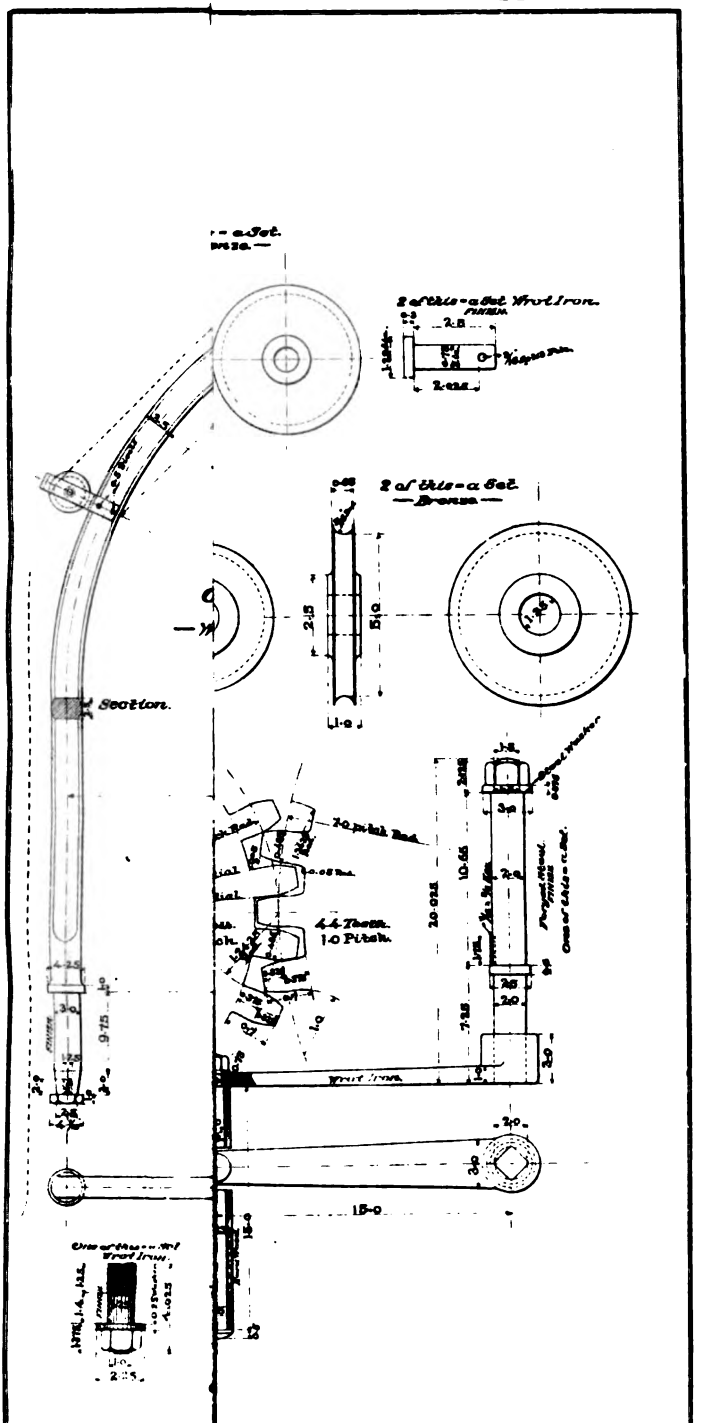

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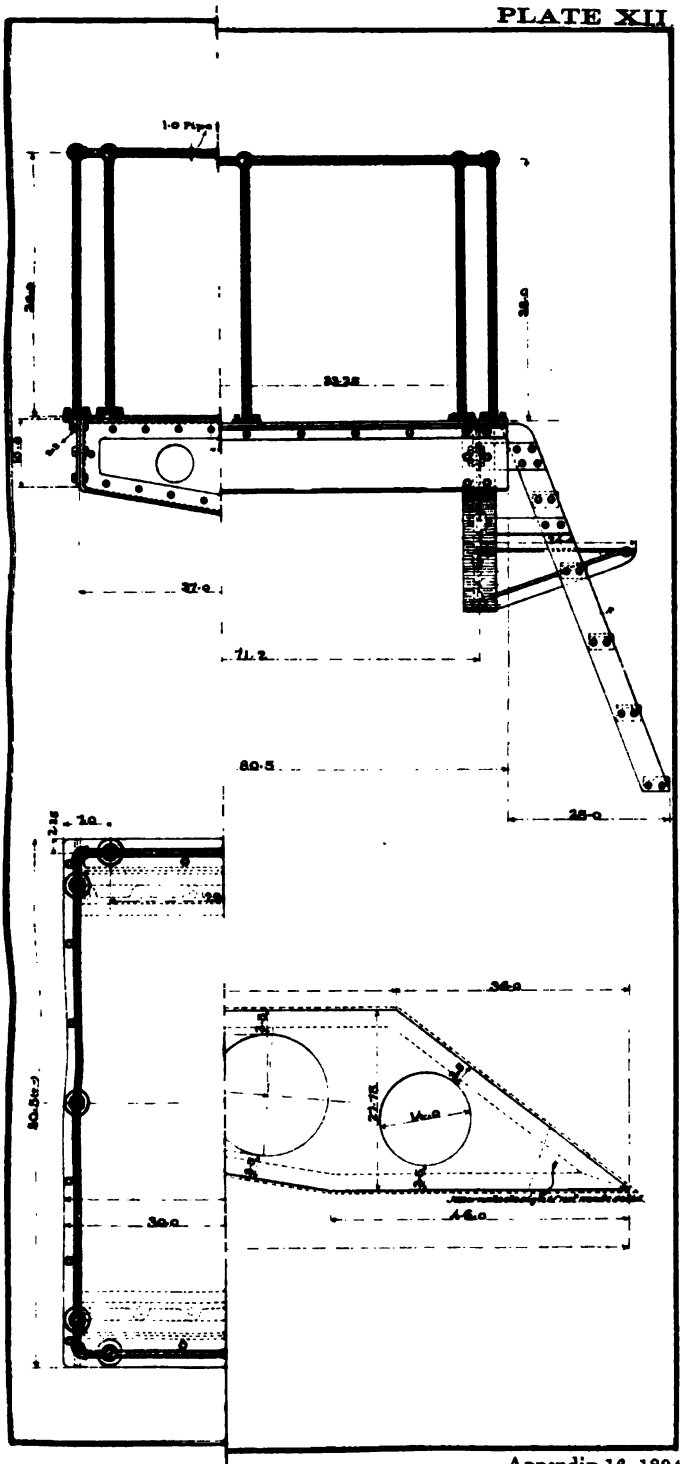

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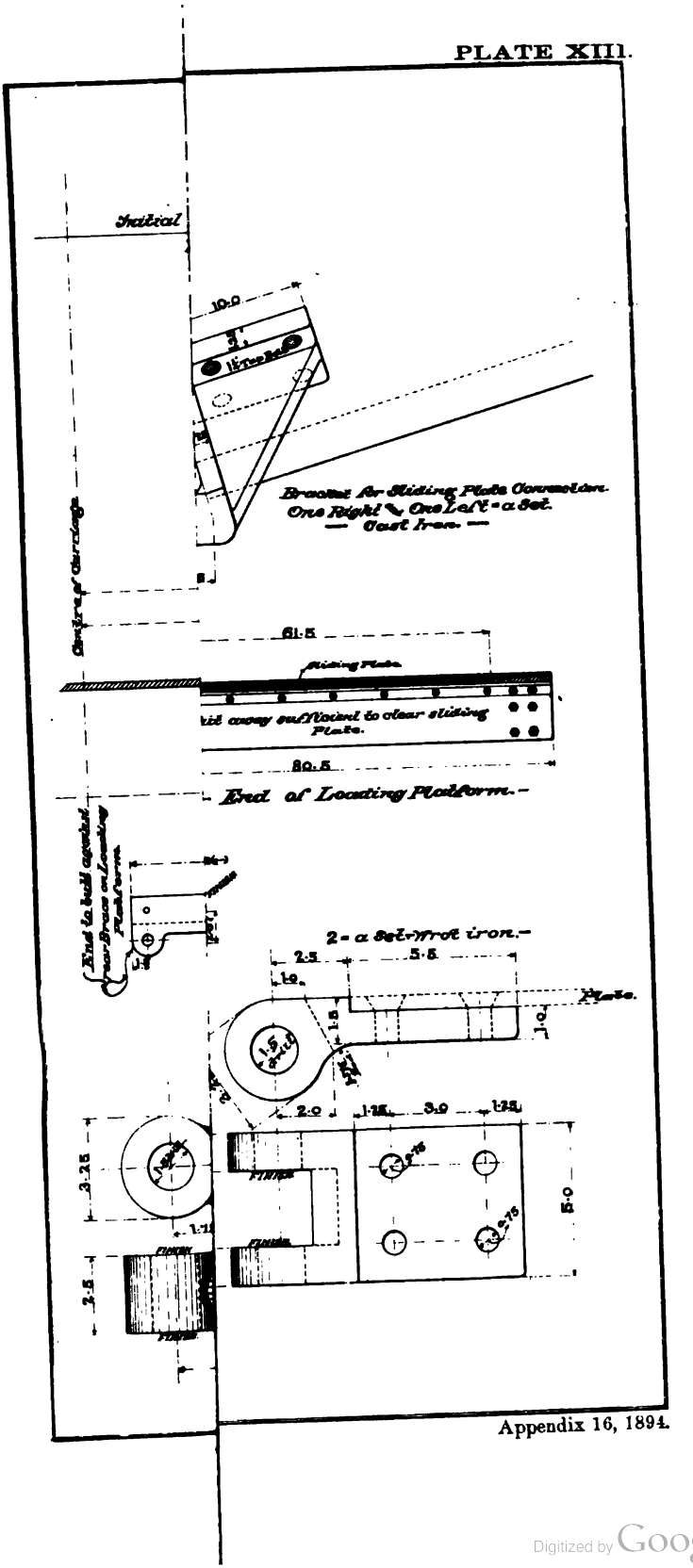

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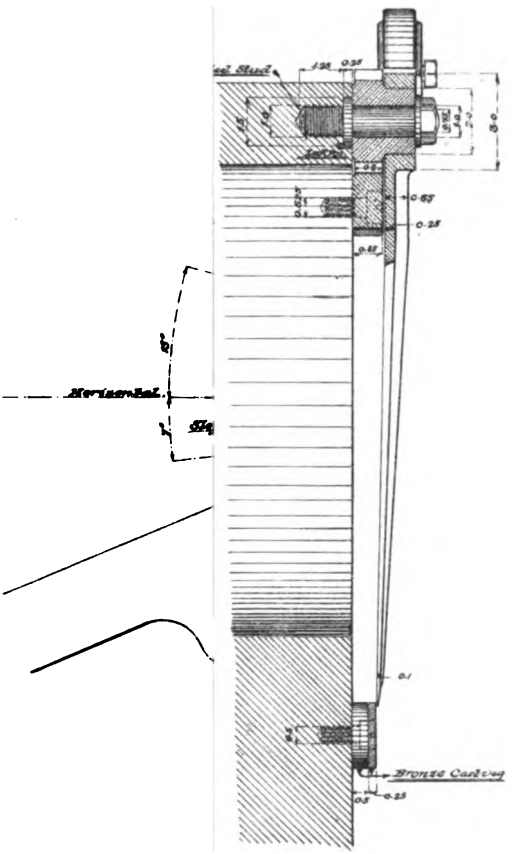

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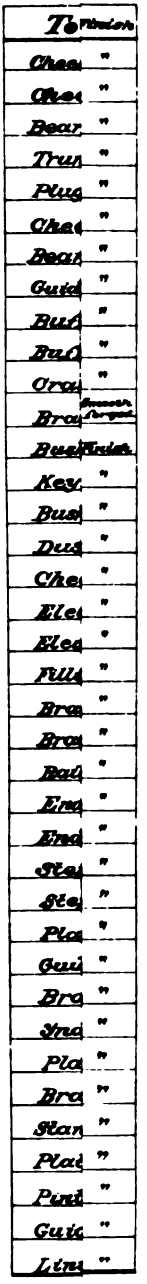

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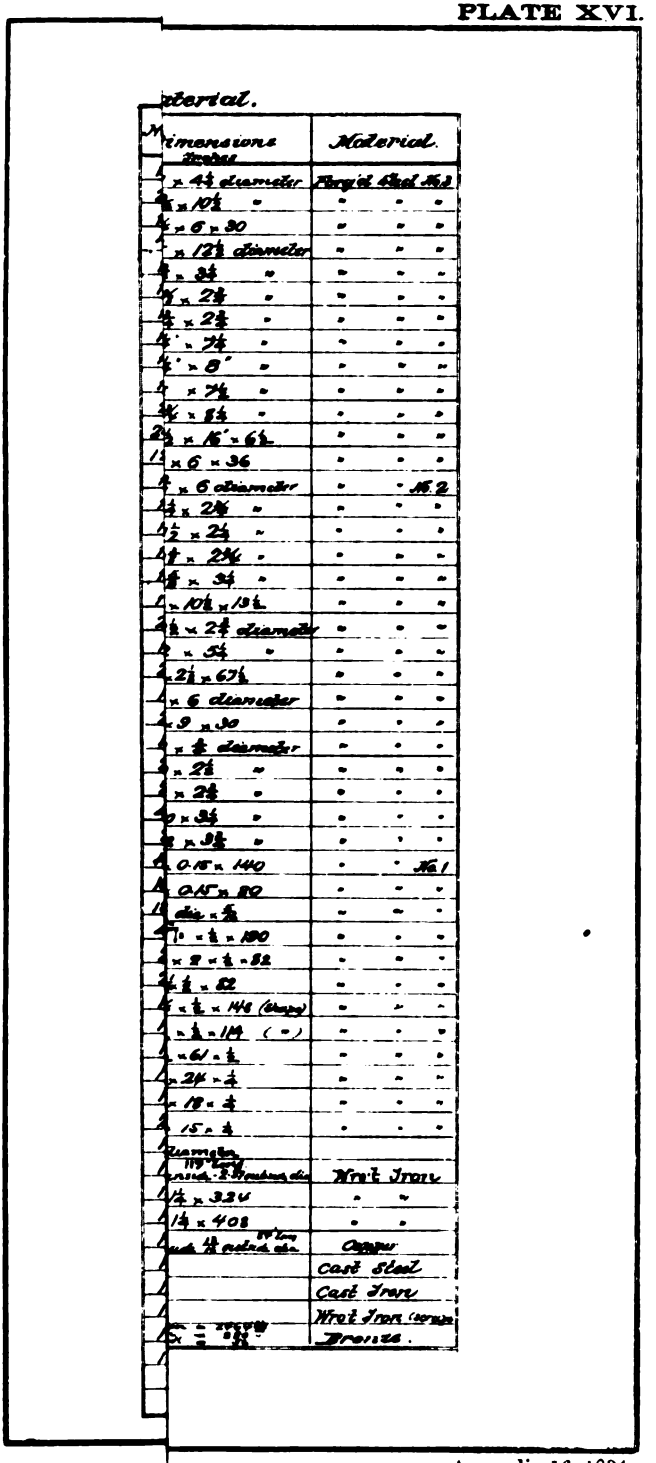

Material.	Dimensions Inches
Forged Steel 55.2	4½ diameter
" " "	10½ "
" " "	6 × 30
" " "	12½ diameter
" " "	3¼ "
" " "	2¾ "
" " "	2½ "
" " "	7¼ "
" " "	8" "
" " "	7½ "
" " "	8¼ "
" " "	16" × 6½
" " "	6 × 36
" " 46.2	6 diameter
" " "	2¾ "
" " "	2½ "
" " "	2¾ "
" " "	3¼ "
" " "	10½ × 19½
" " "	2¾ diameter
" " "	5¼ "
" " "	67½
" " "	6 diameter
" " "	30
" " "	4 diameter
" " "	2½ "
" " "	2¾ "
" " "	3¼ "
" " "	3½ "
No 1	0.15 × 140
" "	0.45 × 80
" "	dia × 5/16
" "	0 × ½ × 180
" "	× 2 × ½ × 82
" "	½ × 82
" "	½ × ½ × 148 (Stamp)
" "	½ × 184 (")
" "	× 6½ × ½
" "	× 24 × ½
" "	× 18 × ½
" "	15 × ½
	Diameter 119 Inches 2 Number dia.
Wrot Iron	¼ × 324
" "	¼ × 408
	Diameter 48 Inches 8 Number dia.
Copper	
Cast Steel	
Cast Iron	
Wrot Iron (screw)	
Bronze.	

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APPENDIX 17.

DESCRIPTION OF DOUBLE HORIZONTAL BORING MACHINE.

(7 plates.)

The bed is made in two halves and bolted together to facilitate the casting; it is open in the middle, to give room for the downward extended portion of the transoms on the barbette top carriages and for the lower cylinder on the 12-inch gun lift.

The side cheeks, upon which rests the top carriage while boring, are bolted to the bed. Graduation at each end of the bed, corresponding to the distance between the centers of the different carriages, will set the side cheeks to the required distance.

The boring bars, which operate in bearings bolted to the top flange of the side cheeks, are actuated by worm wheels, driven by worms. To the worms are attached keys, which fit into keyways made the whole length in the shaft. Each bar is provided with boring head, fed by screws running the whole length of the 6-inch bars. The feed screws are driven by gears and levers, which have slots working on studs attached to the shaft bearings. The feed can thus be manipulated by changing the gears at the rear end of boring bars. The bars are reduced to 5 inches in diameter at the front end in order to bore the stuffing-box end on the carriages. Each end of the boring bars has a sleeve, threaded on the outside, corresponding to the number of threads at the end of the cylinders. To each sleeve is fitted keys running in keyways on the boring bar. There are also back rests, having nuts attached to screws operated by hand wheels. These nuts, when screwed down so the threads at the lower end of the nuts engage those on the sleeves, will advance the sleeves the proper pitch. The front sleeves are also provided with feed gear for boring stuffing-box end, which arrangement is to be detached when threads are to be cut.

By means of loose parallel pieces having dowels let into holes on top flange of side cheeks the vertical distance from the center of the cylinders to the slides can be changed.

Two single cylinders for the altered 10-inch and 15-inch carriages can also be bored in this machine at the same time by providing the machine with chucks to hold them. By this arrangement of boring heads and sleeves the two cylinders of a gun carriage can be bored or threaded at the same time.

The machine is to be driven by two separate countershafts having open and cross belts.

WATERTOWN ARSENAL, *January 16, 1894.*

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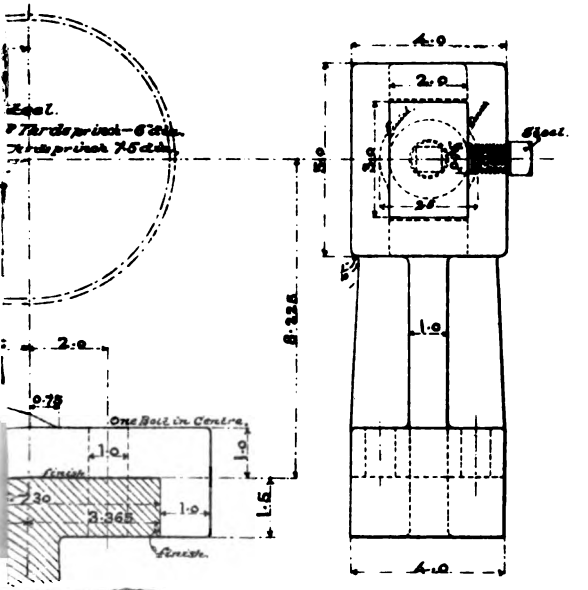
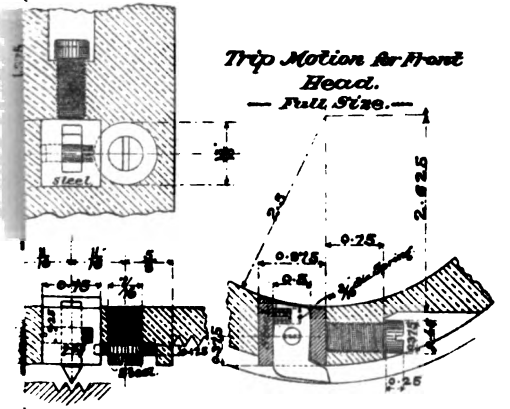
Rest for Cutting Threads.—

2 of this Cast Iron.



Trip Motion for Front Head.

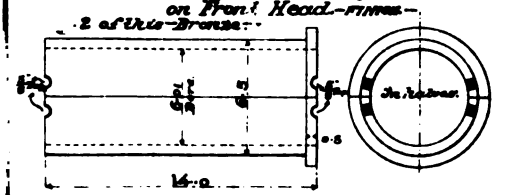
— Full Size.—



— Bushing for Protecting Threads —

on Front Head.—FITTED.—

2 of this Bronze.



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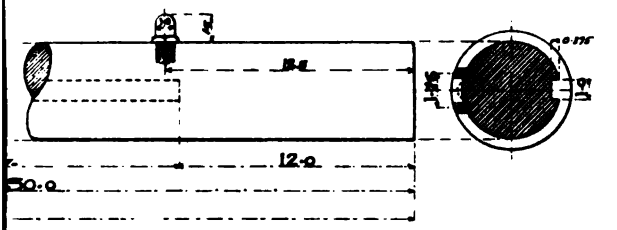
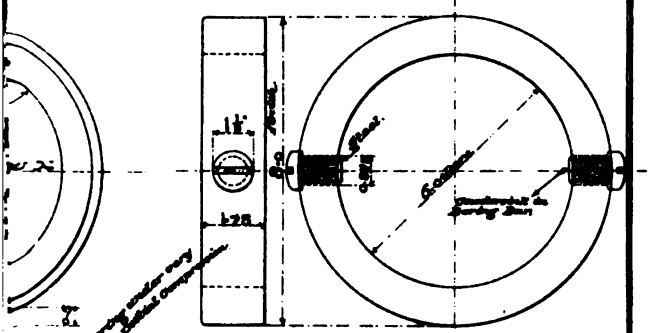
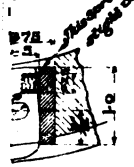


Collars for Boring Bars.
4 of this—Bronze.—





Trip Motion for Rear Head.
— Full Size. —

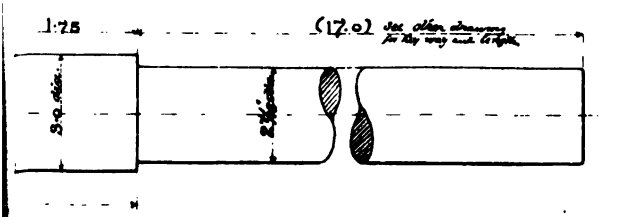


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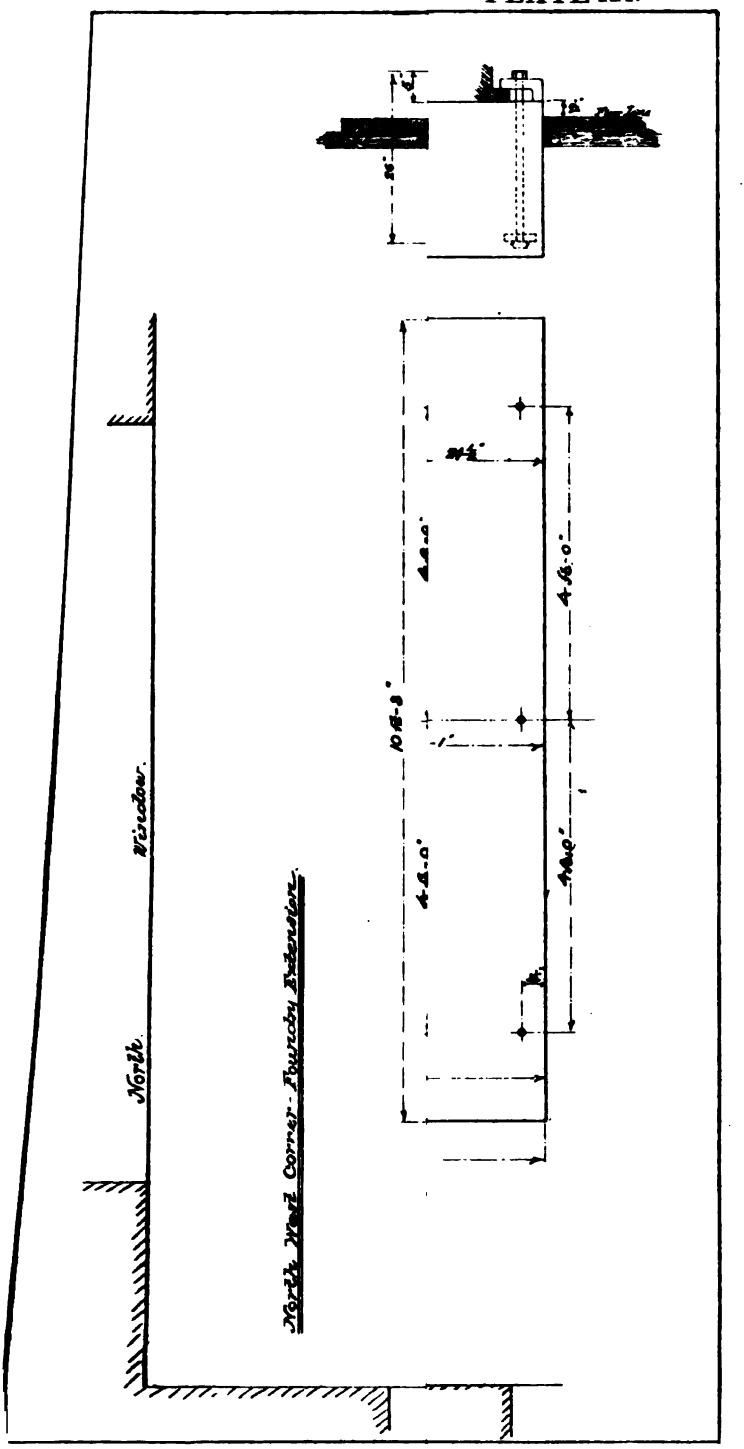
PLATE III.



Appendix 17, 1894.

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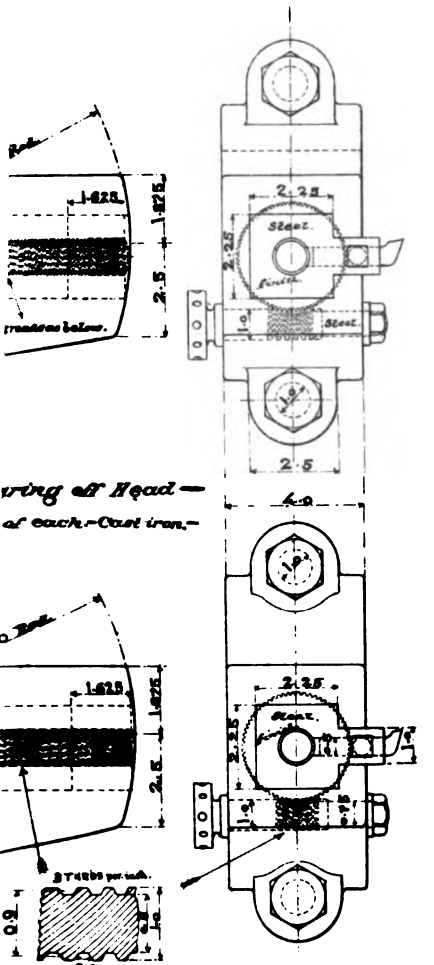

ving of Head —
of each.—Cast iron.—

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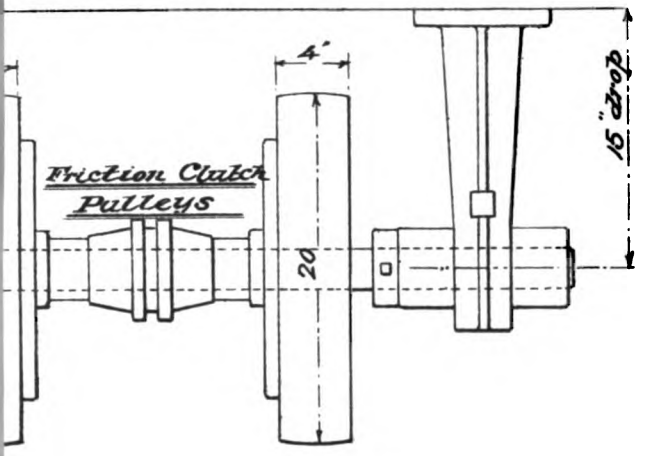

Boring Machine.

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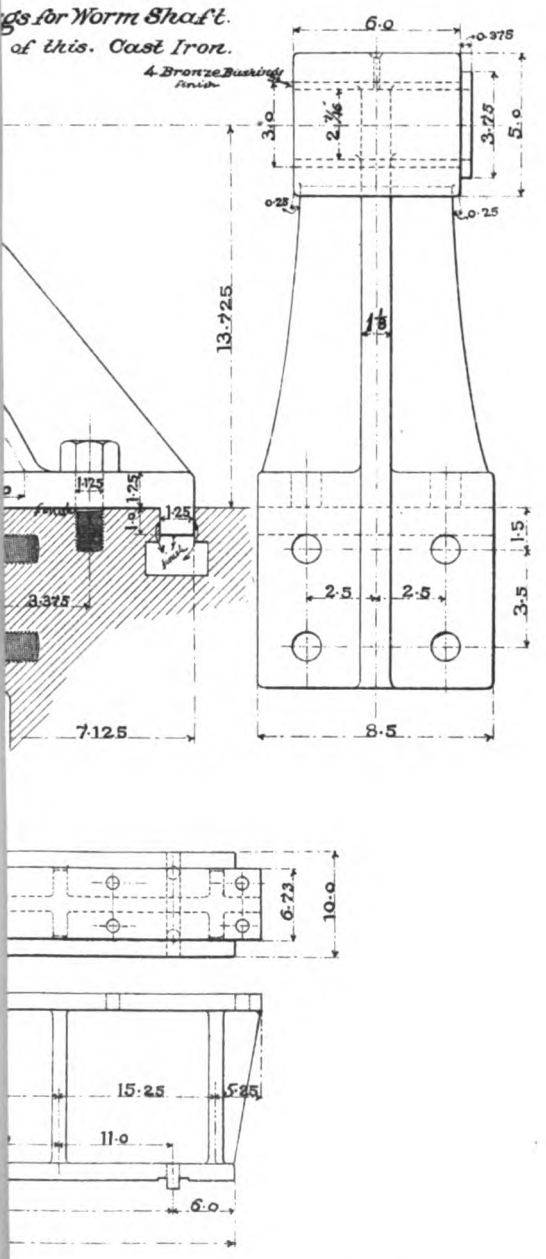

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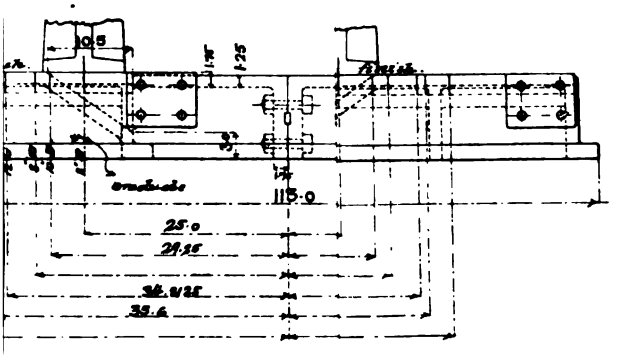

Horizontal Boringe.——

——*Bed Plate.*——

——*Cast Iron.*——

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APPENDIX 18.

REPORT OF PRINCIPAL OPERATIONS DURING FISCAL YEAR ENDED JUNE 30, 1894.

(3 plates.)

SANDY HOOK PROVING GROUND,
(P. O. Box 1449) New York, N. Y., September 4, 1894.

SIR: I have the honor to submit the following report of the principal operations of this post during the fiscal year ended June 30, 1894:

Daily firings have been conducted during the year whenever the weather and other circumstances would permit. The object of these firings and the extent and character of the work done at the proof batteries are summarized in the appended tables.

IMPROVEMENTS.

The facilities for conducting experimental and proof firings have been considerably increased during the year, and the proving ground may be said to be in better condition than ever before for the efficient and quick performance of the duties required of it. The improvements consist in changing to standard gauge the railway system pertaining to the post and connecting the system with the Central Railroad of New Jersey; the building of an explosion chamber of 1,000 cubic feet capacity for use in connection with experiments with high explosives, and the establishment of a plant for the test of a search light for coast-defense purposes. Heavy concrete platforms have been built for the Gruson minimum port carriage for 12-inch B. L. rifles and for the second Gordon disappearing carriage for 10-inch B. L. rifles. Two platform plates have been put in position; on these plates can be tested barbette carriages for 8-inch, 10-inch, and 12-inch rifles; Buffington-Crozier disappearing carriages for 8-inch and 10-inch rifles, and 4.7-inch rapid-fire guns and carriages; also carriages for 12-inch mortars.

RAILWAY.

The Fifty-second Congress, at its first session, appropriated $26,676 for the purchase, from the Central Railroad Company of New Jersey the railroad track, sidings, frogs, switches, etc., pertaining to this company and located on the United States reservation at this place, for Government use by the Ordnance Department. This purchase having been satisfactorily accomplished, it became necessary, in order that it might be utilized to the best advantage, to connect it with the tracks already existing near the proof batteries. It was also necessary to change the width of the latter tracks from narrow to standard gauge, and at the same time to alter their location and change their curves to conform to

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the new conditions. The accompanying map shows the location and extent of the railroad pertaining to this post as it now exists, and by which connection can be made with the Central Railroad of New Jersey and any other point to or from which shipments may be desired. At the point H connection is made with the purchased road. At this point a Y has been constructed, to enable a gun or other piece to be turned in the direction required for convenient handling at the battery. From the point A the new road passes over toward the 3,000-yards target, thence up the beach to the battery, which it enters by the runway of the Gantry crane. By this arrangement the crane can be placed over the car, take therefrom its load, and in a few minutes deposit it at any point in the battery. By means of a switch the main road is continued down to the wharf and up in rear of the battery; also another switch leads along the rear of the wall of the old fort and up to and through a large shed built for the storage of 12-inch mortar carriages.

A turntable allows access to the machine shop, and another at the wharf permits cars to be placed immediately under the 15-ton crane. The work of building this road was performed in a very efficient manner, under the immediate supervision of Lieut. C. B. Wheeler, Ordnance Department.

The use of the road has resulted in great economy in transportation of heavy weights to and from this place. It is known that the cost of transporting a 12-inch gun from the gun factory at Watervliet Arsenal has been reduced from about $1,600 to $275, and of a 10-inch gun from $450 to $150, and the cost of other shipments is reduced to like proportion. Guns, carriages, and other heavy weights are constantly being received over this road, and the depot quartermaster at New York City informs me that the saving to Army transportation can not be less than $25 000 during the fiscal year, and it will probably be much greater.

To place this road in perfect working condition requires that means be provided for protecting that portion, about 1,500 feet in length, which lies on the narrow neck connecting the reservation with the mainland. During the violent storms which prevail during the late winter and early spring months this neck is submerged by the waves, which tear up the tracks or cover them with sand and débris. Several times after the completion of the road as above described, and as late as May 21, 1894, the tracks were thus ruined, and great expense was incurred in keeping them in repair. This difficulty could be overcome by building a heavy bulkhead filled with stone along and parallel to the track, and of sufficient height to prevent the waves passing over it. Another method would be to raise the tracks about 5 or 6 feet by means of piling and allow the waves to pass under them. The latter method is considered equally efficient and would cost much less than the former.

For use in connection with the railroad a locomotive engine has been purchased, the Fifty-second Congress at its second session having appropriated $3,500 therefor. The engine was manufactured by the Baldwin Locomotive Works, of Philadelphia, Pa. It is a 4-wheel saddle-tank locomotive, fitted with steam brake and headlight. It is of standard gauge, and burns anthracite coal. The cylinder is 9 by 14 inches, and the diameter of driving wheel 33 inches. Its weight is about 28,000 pounds, and hauling capacity on a level 760 tons. This engine has been in constant use, and has been found satisfactory in every respect.

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EXPLOSION CHAMBER.

For use in connection with the test of high explosives and for other purposes when it is desired to collect the fragments resulting from the bursting of charged shells, a large and very strong chamber has been built. This chamber, though adapted to much heavier work, is modeled after that in use by the Navy at the Indian Head proving ground, a drawing and description of the latter having been furnished by the Chief of the Bureau of Ordnance of the Navy. The chamber is constructed of sheets of mild steel built up of double plates each 1 inch thick; the interior sheets vary in width from 36 inches to 24 inches, and are laid vertically; the outside sheets are 12 inches wide, and are laid horizontally, joint crossing joint at right angles. All angles formed by the sides and entrance are secured with 1-inch angle irons, bolted through both thicknesses of plating with 1-inch bolts. The steel lining is backed on all sides by yellow pine 12-inch timbers, and secured to the lining by through bolts 1½ inches in diameter, nuts outside, and heads on inside countersunk; these bolts further secure all exposed joints inside of chamber. The chamber has a capacity of 1,000 cubic feet, and is vented by an open entrance 10 feet high and 1½ feet wide, and two rectangular vents constructed on the deck of the chamber each 6 feet long, 10 feet deep, and 12 inches wide. The deck vents are formed of ½-inch steel plate, each side being composed of a single plate secured to 12-inch channel upright, and secured to the deck by heavy 12-inch channel beams bolted securely to the inside lining. The vents are stayed together by wrought-iron stays. A 3-inch wrought-iron pipe passes up through the stays, and is secured to the lining at the lower end; through the pipe the battery wires are passed for securing electric connection with the charge to be fired. The yellow-pine timbers are one-half checked together at the angles, 12 inches from the ends of the timbers, as shown by the drawing. Through bolts 1½-inches diameter pass from deck to floor through the sides, and iron binding plates 6 inches wide and 1 inch thick clamp sides, deck, and floor firmly together. The chamber is entered by a zigzag passageway lined for 4 feet at end next to the chamber by a continuation of the interior plating, the remainder being built up of 12-inch yellow pine timbers laid horizontally and firmly bolted to the steel lining and secured top and bottom with binding plates and through 1½-inch bolts. The mouths of the deck vents are protected by channel-iron deflecting plates secured to a continuation of the upright by angle irons and bolts, making them easily removable if destroyed. The chamber is buried in sand to a height of 9 feet from its deck, so that the surface of the ground is level with the mouths of the deck vents. The chamber when in use is lined with rough 3-inch spruce boards; these act as buffers for the fragments of the exploded shell, and prevent the scoring and indenting of the steel lining which would otherwise occur.

This chamber, complete drawings of which are now on file in your office, has already been put to successful use in determining the character of the explosion of certain explosive substances when fired under varying conditions.

SEARCH-LIGHT PLANT.

During the year a plant has been established at this post for determining the practical use to which a powerful search light may be put as an auxiliary in seacoast defense. The plant consists of one search light complete with a parabolic glass mirror 60 inches in diameter and furnished with a horizontal self-focusing arc lamp. The apparatus is

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provided with a mechanism which permits of both horizontal and vertical motion by either hand or electric power. These motions can be controlled from a distance, a suitable governor being provided for the purpose. By means of a metallic shutter the light may be used for signaling purposes.

One steam engine of 20-horse power, arranged for direct coupling with a dynamo of 160 ampères and 70 volts, the whole being of sufficient capacity to produce an intensity of light equal to about 200,000,000 candle power. Special measuring and controlling devices, such as voltmeter, ampereometer, safety fuzes, rheostate with switch-board, etc., are provided as part of the plant.

The steam engine and dynamo are located near the boiler pertaining to the machine shop, the light is mounted upon a tower located on the southeast corner of the old fort at this place. The tower is constructed square in plan, 24 feet at base and 12 feet at top. It is made in four sections or floors, the uprights or legs in each section being of 10 by 10 inches yellow pine timbers 15 feet long, each timber terminating in a cast-iron socket at each floor. The cast-iron sockets form at each corner of the several stories a series of pockets into which the floor beams and diagonal struts are bolted. These sockets are also provided with lugs cast on and suitably placed for a system of wrought-iron ties or braces; these ties are 1½-inches in diameter and run diagonally, embracing two stories each, and crossing each other midway between each story. The struts are of 8 by 8 inches yellow-pine timber; they extend diagonally from corner to corner of each bay and complete the external structure of the tower. The tower is anchored to the fort wall by 1½-inches iron bolts. The upper ends of the bolts pass through lugs in the cast-iron sockets at top of the first bay; the lower ends pass into the granite of the wall, being secured by lead run in. Set pins also pass through lugs in the base shoes into the granite, being run in with lead. The tower is provided with a suitable stairway, giving easy access to the top or lamp platform, which is strongly built of 3-inch planking securely fastened to the floor beams and provided with a hatchway. Beneath the floor is placed a box for the signal shutter and dispersing lens. The lamp stands on a raised foundation 8 inches high, and the entire platform is surrounded by a galvanized iron pipe hand railing.

A plane table house has been built in the first bay, and so located as to clear ties, struts, etc., on three sides and give to the observer a perfect view over a greater range than has heretofore been attainable.

Drawings of the tower are now on file in your office.

Accompanying this report is a photograph showing tower and search light complete, also a photograph showing the locomotive and two 10-inch B. L. rifles mounted on cars as received from the gun factory, Watervliet Arsenal.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(1894)

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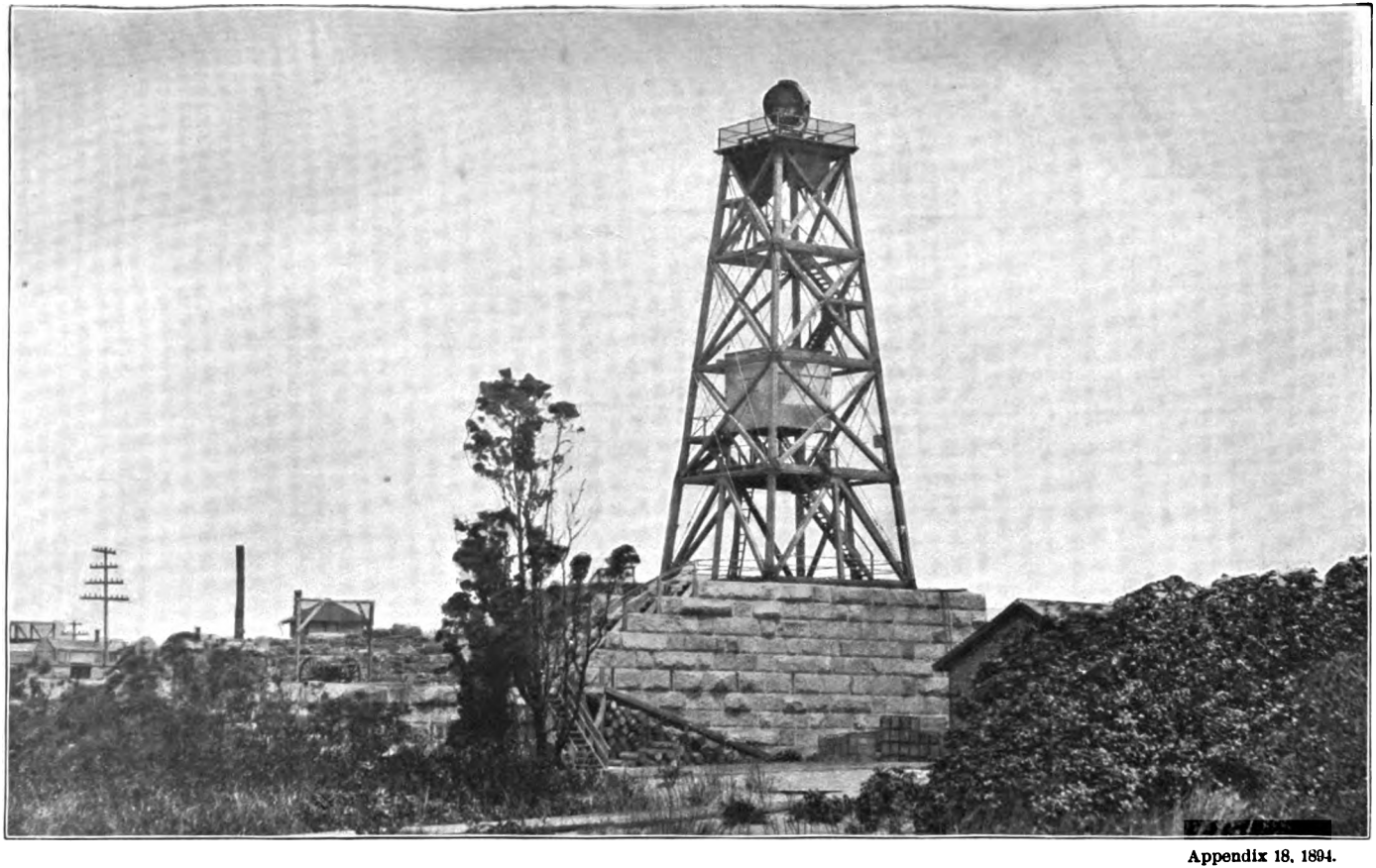

Appendix 18, 1894.

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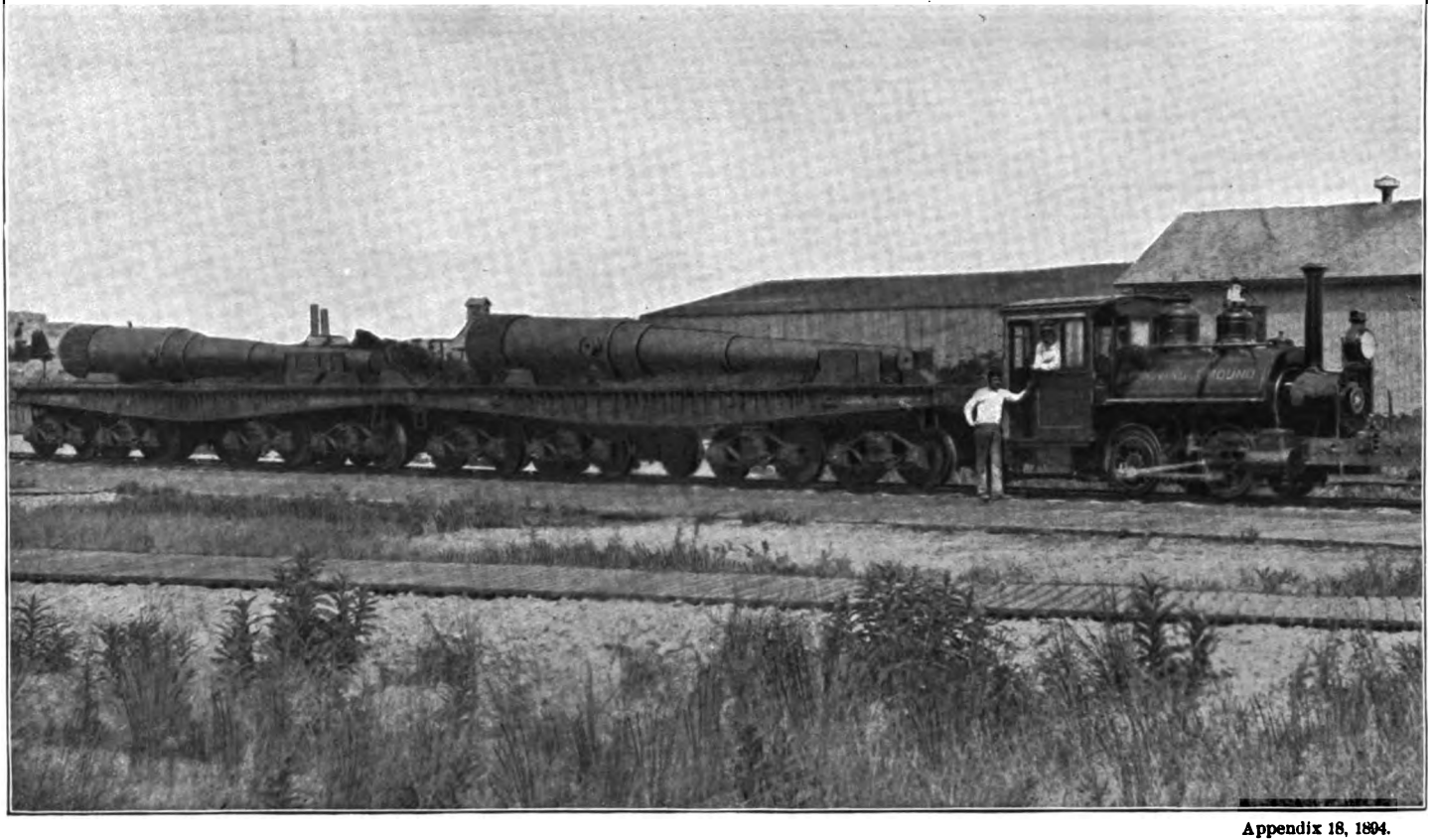

Appendix 18, 1894.

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TABLE I.—*Rapid-fire guns.*

[Items in bold-faced figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	Breech-loading rapid-fire rifles.									Total.
			6-pounders.							
	Multicharge 2.5 inches (Bryan, Birmingham, Ala.).	Mitrailleuse (Skoda, Pilsen, Austria).	3-pounder (Skoda, Pilsen, Austria).	Sponsel, Hartford, Conn.	Maxim-Nordenfelt, London, England.	Hotchkiss, Hartford, Conn.*	50-caliber (Hotchkiss, Paris, France).†	Driggs-Schroeder, Philadelphia, Pa.	12 centimeters, 4.7-inch (Armstrong, Newcastle, England).	
To obtain velocities and pressures	2									2
Test of breech mechanism	6									6
Test of gun		600	322	389	347	370		451		2,471
Test of fixed ammunition loaded with French smokeless powder							3			3
Exhibition of gun before Senator Hawley, of Connecticut									2	2
Total	6	600	322	389	347	370	3	451	2	

* Total length of gun, 108.86 inches.

† Total length of gun, 112.2 inches

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TABLE II.—*Field and siege guns.*

[Items in bold-faced figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	Muzzle-loading rifle, 3-inch wrought iron, Pittsburg Iron Co.	Breech-loading rifles, steel.									Total.
		Paris, France.		Watervliet Arsenal.					Watertown Arsenal.		
		1.65-inch Hotchkiss.	75-millimeter Hotchkiss.	3.2-inch Driggs-Schroeder.	3.2-inch Gerdom.	3.2-inch service.	3.6-inch service.	3.6-inch type.	5-inch siege type.	7-inch howitzer type.	
Examination of Hotchkiss system of field artillery			6								6
Exhibition of gun before the American Society of Civil Engineers						3					3
Proof of gun				56							56
Proof of powder		8		6		16					30
Test of—											
Hotchkiss fuses	17										17
Frankford Arsenal fuses		12				15				34	61
Driggs fuses						15					15
Griswold fuses							5	9			14
Brenchard & Gillespie fuses										13	13
Fuzes for high explosives								6			6
Fixed ammunition		15		50							65
Driggs-Schroeder breech mechanism				56							56
Gerdom breech mechanism					6						6
Seabury breech mechanism									37		37
Method of banding projectiles						21	24				45
Electric welded shrapnel						28 / 8					36
Frankford Arsenal shrapnel						110 / 23					133
Raskazoff disappearing carriage									37		37
Service carriage										8 / 77	85
French quadrant										1	1
To determine jump of gun						24					24
To determine accuracy of projectiles								19		30	49
To obtain velocities and pressures		10	4			22				12	48
To obtain targets		30				26					56
To obtain data for range table						61					61
Total	17	75	10	56	6	341	29	34	37	98	

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TABLE III.—*Mortars.*

[Breech-loading rifled mortars. The items in bold-faced figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	3.6-inch steel, Watervliet Arsenal.	12-inch cast iron, Builders Iron Foundry.	12-inch steel, Watervliet Arsenal.	12.2-inch cast iron, South Boston Foundry.	Total.
Exhibition of mortar before—					
Maj. Gen. N. A. Miles, U. S. Army	.....	.....	1	.....	1
American Society of Civil Engineers	.....	.....	2	.....	2
Chief of Ordnance U. S. Army	.....	.....	1	.....	1
For the information of Lieut. W. P. Duvall, Fifth Artillery, U. S. Army	.....	.....	1	.....	1
Proof of mortars	.....	134 / 8	.....	.....	142
Test of—					
Modified gas check cups and steel split rings	.....	.....	19	.....	19
Spring-return mortar carriages	.....	4 / 48	7 / 86	.....	140
Spiral springs for spring-return carriages	.....	.....	37	.....	37
Griswold fuses	.....	.....	2	.....	2
Frankford Arsenal fuses	22	.....	7	.....	29
Fuses for high explosives	.....	6	.....	.....	6
Emmensite	.....	.....	.....	5	5
Hotchkiss base percussion fuses	3	.....	.....	.....	3
Wheeler-Sterling 12-inch deck-piercing steel shell	.....	15	.....	.....	15
Hadfield 12-inch deck-piercing steel shell	.....	2	.....	.....	2
Midvale-Holtzer 12-inch deck-piercing steel shell	.....	1	.....	.....	1
To determine flight of shell	.....	8	.....	.....	8
To obtain data for range table	.....	33	83	.....	116
To obtain velocities and pressures	.....	9 / 9	13	.....	31
Total	25	212	136	5	.....

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TABLE IV.—*Seacoast guns.*

[Items in bold-faced figures show that the rounds were fired with two objects. These rounds are not counted in the total for gun.]

Object of firing.	B. L. segmental wire-wound 5-inch, Brown, Diamond Drill Co.	Muzzle-loading rifles.		Breech-loading rifles, steel.								
		Wrought iron 7-inch Ames (H. Ames, 1865).	Cast iron 8-inch converted, West Point Foundry.	8-inch type, Watervliet Arsenal.	9-inch service, West Point Foundry.	Watervliet Arsenal.						
						8-inch service.	10-inch wire-wound, Woodbridge.	10-inch type.	10-inch service.	12-inch type.	12-inch service.	Total.
Exhibition of gun before—												
Maj. Gen. N. A. Miles, U. S. Army						2		1				3
The Board of Ordnance and Fortification	2							1		3		6
Observe the effect of high-explosive bursting charge, without fuse, against armor plate		5		1								6
Proof of guns	29 / **147**				47	34 / **17**	23	27	74 / **84**	25	4 / **30**	491
Proof of powder	138			30	3 / 8	2	23	2	30	14	13	263
Test of—												
Modified gas check cup and steel split rings					4				1			5
Altered 15-inch carriage to receive 8-inch B. L. rifle, steel					6							6
Buffington-Crozier 8-inch disappearing carriage				65		21						86
Gordon 10-inch disappearing carriage, No. 1								18 / **1**				19
Gordon 10-inch disappearing carriage, No. 2									10			10
Schneider-Creusot 12-inch carriage										25		25
Grusonwerk 12-inch minimum port carriage											6	6
Gun-lift battery										5 / **25**		30
Carpenter 12-inch steel armor-piercing shot											7	7
Midvale Holtzer—												
8-inch steel armor-piercing shot				10	7							17
10-inch steel armor-piercing shot								5	2			7
12-inch steel armor-piercing shot											4	4
Accuracy of gun						17						17
Clark's exploder			5									5
Fuses for high explosives	3	4										7
French smokeless powder										3		3
To obtain velocities and pressures	4											4
Total	176	9	5	105	61	53	23	27	117	25	34	

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APPENDIX 19.

SUMMARY OF TESTS OF SMOKELESS POWDERS.

SANDY HOOK PROVING GROUND,
(*P. O. Box 1449*) *New York, N. Y., September 18, 1894.*

SIR: In accordance with your instructions of September 1, I have the honor to submit a summary of tests of smokeless powers made at this post during the fiscal year ended June 30, 1894.

The report from this office dated August 31, 1893, and forming Appendix 30 of your annual report for 1893, contains a full and complete report of tests made up to August 18, 1893. Since that date, with the exception of two rounds fired from the 8-inch rifle with German smokeless powder, the tests have been confined exclusively to samples furnished by the Leonard Smokeless Powder Company, the object being to observe the effect of changes in the proportions of the ingredients and the size and form of the grains.

The results may be tabulated as follows:

5-inch Brown segmental wire-wound gun.

[Kind of powder, Leonard's smokeless.]

Number of rounds.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
	Pounds.	*Pounds.*		*Pounds.*	
1	13	62	2,219	Less than 18,000	Original Leonard formula.
1	24	61 $\frac{1}{16}$	2,115	Less than 40,000	
1	15	61	2,061	19,680	N. C. Ruby. Red powder; rods 40 inches long, 0.75 inch diameter.
1	25	61	2,791	40,060	
1	15	61	1,957	17,168	
1	25	60 $\frac{1}{16}$	2,663	34,707	
1	30	60 $\frac{1}{16}$	3,128	53,500	
1	30	45	3,024	40,170	
1	15	61 $\frac{1}{16}$	1,568	14,024	C. A. containing an excess of gun cotton.
1	13 $\frac{11}{16}$	61 $\frac{1}{16}$	2,071	21,865	C. 6 experimental rifle powder.
1	25	62	2,482	28,954	C. A. containing an excess of gun cotton. Ruby. Rods 40 inches long, 0.75 inch diameter.
1	30	62	2,893	49,795	
1	32	60 $\frac{1}{16}$	3,110	52,934	
1	32	61	2,977	48,832	
1	32	61	2,541	29,839	Ruby C $\frac{+}{88}$, experimental formula No. 8, containing linseed oil.
1	25	61	1,816	28,000	Ruby C $\frac{+}{88}$.
1	30	61	2,711	35,478	Ruby C. Natural color. Rods 42 inches long, 0.75 inch diameter.
1	30	61	3,235	65,313	
1	15	61 $\frac{1}{16}$	2,262	Less than 14,000	Ruby X 7, experimental, with reduced amount of linseed oil.
1	30	61 $\frac{1}{16}$	2,701	35,200	
1	34	61	3,015	48,111	
1	36	62	3,130	56,043	

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3.2-inch B. L. rifle (Driggs-Schroeder).

Number of rounds.	Charge.	Projectile.	Muzzle velocity	Pressure.	Remarks.
	Pounds.	*Pounds.*		*Pounds.*	
1	1	13 1/16	1,274	10,500	Experimental powder. No. 8. Natural color; 1/8 inch diameter, tubular.
1	1	13 1/16	1,432	14,875	
1	1 1/16	13 1/16	1,590	15,000	
1	1 1/16	13 1/16	1,830	18,250	
1	1 1/16	13 1/16	1,780	20,830	
1	2	13 1/16	1,937	24,400	

6-pounder Driggs-Schroeder rapid-fire gun.

1	1/16	6	1,310	Less than 9,000	Natural color, cylindrical, 10.25 inches long, 0.36 inch diameter.
1	1/16	6	1,692	11,321	
1	1	6	2,019	Less than 18,000	
1	1 1/16	6	2,243	Less than 24,000	
1	1 1/16	6	2,491	29,200	
1	1 1/16	6	2,575	33,250	
1	1 1/16	6	2,575	33,492	

It is believed that this company is endeavoring to respond to the demand for a smokeless powder with a reduced proportion of nitroglycerin. The ballistic qualities of this powder have maintained the high standard acquired during the preceding year.

GERMAN SMOKELESS.

In continuation of the experiments to test the effect on this powder of long storage, two rounds were fired from the 8-inch rifle, as follows:

8-inch B. L. rifle, steel, model 1888, Watervliet Arsenal.

[Kind of powder, German smokeless.]

Number of rounds.	Charge.	Projectile.	Muzzle velocity.	Pressure.	Remarks.
	Pounds.	*Pounds.*		*Pounds.*	
1	45	300	1,965	30,945	Rifle No. 9.
1	46	302 1/16	2,018	31,770	Rifle No. 11.

The results compared with those noted on page 397 of your report for 1893 indicate that this powder when stored in hermetically sealed cases can be kept for a period of two years and ten months without material deterioration.

Samples smokeless powders have recently been received from the Walsrode Smokeless Powder Company, of New York, for field guns; and from the Vereinigte Koeln-Rottweiler Pulver-fabriken, of Cologne, Germany, for 8-inch and 12-inch B. L. rifles.

These powders have not at this date been tested.

Very respectfully, your obedient servant,

FRANK HEATH,

Captain, Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,

Washington, D. C.

(2323)

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APPENDIX 20.

REPORT OF FIRINGS MADE WITH WOODBRIDGE 10-INCH B. L. RIFLE, WIRE WOUND.

SANDY HOOK PROVING GROUND,
(P. O. Box 1449) New York, N. Y., May 10, 1894.

SIR: I have the honor to submit the following report with reference to the firings made up to date with the 10-inch B. L. rifle, Woodbridge, wire wound, steel. These firings have in all cases been made for the purpose of testing samples of powder furnished by the Messrs. Du Pont for this gun under their contracts with the Department. The first test was made on the 15th September, 1893, and others have been continued from time to time as the samples were received. From the beginning difficulties were encountered, due to the peculiar action of the breech-block, which required the efforts of three men to pull it out and push it back again into position; also to the fact that the chamber and rifling were not connected by a proper forcing cone, and as a result, in ramming, the shot tended to wedge in the bore, and the labor of loading was thereby greatly increased. It should be noted, however, that in every instance the greatest care was taken to insure the proper seating of the shot before the gun was fired. The difficulty was to some extent overcome after the sixteenth round by the use of a loading tray sufficiently long (76 inches) to extend to the forward end of the powder chamber. The weight of this tray was 84.5 pounds.

On the 24th April, 1894, after the twenty-third round, while opening the breechblock preparatory to another round, a small quantity of what appeared to be liquid residue was discovered oozing from the breech end of a joint between two segments. The residue was ejected explosively, being thrown about 2 feet to the rear of the breech, thus indicating considerable pressure. The gun was cleaned out and the condition of the bore found to be as follows: A crack in the tube just to right of lowest element begins 3 feet 4 inches from breech and extends forward nearly 4 feet 6 inches in a straight line, then turns obliquely to the right, crosses one land and part of adjacent groove, then separates into two irregular ring cracks, one to the right and the other to the left, the former crossing four grooves and three lands and the latter four lands and three grooves. This crack is about $\frac{1}{16}$-inch wide at widest part. A second crack just to left of upper element begins 3 feet 3 inches from breech and extends forward in a straight line 4 feet 9 inches, when it turns to right, forming a ring crack crossing five grooves and five lands. This crack is about the same width as the first. A third crack, about halfway between right and lower element, begins about 23 inches from breech and extends forward about 18 inches. This is a very fine crack. A fourth crack, very fine, just to left of lower element, begins 3 feet 6 inches from breech and extends straight forward 2 feet 4 inches. A

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fifth crack, fine, just to right of upper element, begins 3 feet 8 inches from breech and extends forward 2 feet 6 inches. The principal cracks are the first and second. They both extend into the rifling, the former 19 inches, the latter 14½ inches. The land which the first crosses just before separating appears to be torn away from the surface of the bore, so that it is seen projecting upward as viewed from the breech. It is worthy of note that each crack appears to lie in the plane of the junction of two adjacent staves.

Impressions have been carefully made of the bore and chamber sufficient to determine the form and position of the cracks above noted. These impressions also indicate that cracks not observed by the eye exist at the roots of the sharp angles which separate the lands and grooves, respectively.

An analysis of the pressures to which this gun has been subjected shows that of the 23 rounds fired 1 round was with a pressure of 24,000 pounds; 1 round with a pressure of 29,200 pounds; 3 rounds with pressures between 30,000 and 35,000 pounds; 10 rounds with pressures between 35,000 and 40,000 pounds; 6 rounds with pressures between 40,000 and 45,000 pounds; 1 round was with a pressure of 47,167 pounds; 1 round was with a pressure of 47,930 pounds.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(1964–E–'94)

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Record of firing with 10-inch B. L. rifle, Woodbridge wire wound (steel),

[Object of firing,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation or depression.	Instrumental velocity, 250 feet from muzzle.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs. Oz.*	*Inches.*	*Elevation.*	*Feet.*	*Pounds.*
Sept. 15	1	Du Pont's brown prismatic W. H., lot 2; density, 1.835.	168 0	1,772 7	Cored shot, lot 324, rebanded.	570 0	245.682	35	1,559 1,572	D, 24,240 U, 24,160
Sept. 15	2		200 0	2,111 7		570 0	245.682	37	1,743 1,745	D, 30,440 U, 30,740
Sept. 15	3		235 0	2,487 7		568 0	245.807	37	1,943 1,955	D, 45,540 U, 43,400
Sept. 15	4		230 0	2,432 7		570 0	245.807	37	1,912 1,919	D, 40,660 U, 40,000
									175+$\frac{1}{32}$	
Oct. 13	5	Du Pont's brown prismatic W. S., lot 3; density, 1.850.	115 0 115 0	1,239 1,231	Cored shot, lot 324.	566 0	245.682	*Depression.* 15	1,750 1,770	M, 28,200 N, 30,200
			230 0	7						
Oct. 14	6		125 0 125 0	1,345 1,339		568 0	245.682	15	1,947 1,941	* M, less than 32,000 N, 35,100
			250 0	7						
Oct. 14	7		130 0 130 0	1,399 1,393		568 0	245.682	15	1,951 1,952	* M, less than 32,000 N, 36,430
			260 0	7					175+$\frac{1}{32}$	
Oct. 26	8		135 0 136 13	1,452 1,466		566 0	245.682	*Elevation.* 6	2,073 2,077	F, 36,400 X, 38,500
			271 13	7						

* Probable pressure.

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at Sandy Hook Proving Ground, September 15 to November 28, 1893.

proof of powder.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Ft. In.*			
5 10	5 10	Barometer, 30.13; thermometer, 73; humidity, 86.	No. 4 stamped on base of shell. Copper cylinders of 18,000 pounds initial compression and tables of 1890.	Gun mounted on 10-inch proof carriage. Obturating friction primers. Fired into sand butt No. 1. The shot were all gauged before firing. French quadrant used. The rear gas-check cup was not calipered before firing, but two strips of brown paper could be inserted between it and its seat, indicating that it was slightly too small. This idea is confirmed by the firing, as the copper on the pad next to the rear cup was forced out considerably beyond the cup, and it is only a question of time until the copper will be cut through. The gas was evidently more checked by the copper than by the rear cup. It requires 3 men to pull out and push in the breech-block. Two men can do it by making a great effort. The latch has a tendency to open when the block is being pulled out, causing the block to jam, and requiring that it be pushed back again and the latch held down. In the last three rounds the tray flew open at discharge. The catch on the rotating handle works with some awkwardness. The rifling in the shot chamber not being coned, and the powder chamber being somewhat larger than the 10-inch Watervliet guns in diameter, makes it extremely difficult to ram the shot to its seat. The shot in moving from the bottom of powder chamber up into the bore is so much inclined to the bore that it jams on the rifling, and in the last round 9 men were required to ram it to its seat; this should ordinarily require 3 or 4 men. The projectiles being rebanded should have weighed 575 pounds, and no explanation can be offered for the difference in weight unless it be the difference in the scales used. They were, however, balanced properly and the weights recorded as given. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, assistant proof officer.
5 11	5 11		No. 12 stamped on base of shell. Copper cylinders of 28,000 pounds initial compression and tables of 1890.	
6 0	6 0		No. 273 stamped on base of shell. Copper cylinders of 32,000 pounds initial compression and tables of 1890.	
6 0	6 0		No. 6 stamped on base of shell. First primer failed to ignite charge. Gun hung fire on second primer. Copper cylinders of 32,000 pounds initial compression and tables of 1890. The pressure in this round would indicate that the pressure of 43,400 pounds in the third round is about right. Pintle tongue is up in front ¼ inch.	
6 0	6 0	.....	Console flew open and closed again at discharge. Copper cylinders of 28,000 pounds initial compression and tables of 1890.	Gun mounted on 10-inch proof carriage. Obturating friction primers. Fired to sea. Velocities and pressures taken by Lieut. C. B. Wheeler, Ordnance Department. Firing conducted by the proof officer.
6 1	6 1	.....	Copper cylinders of 32,000 pounds initial compression and tables of 1892.	
6 2	6 2	.....	Gun hung fire. Copper cylinders of 32,000 pounds initial compression and tables of 1892.	The charge used was calculated to give a pressure of 40,000 pounds per square inch from data obtained in previous firings with the same powder. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, assistant proof officer.
6 1¾	6 1¾	.....	Battering ram used to force shot home. Copper cylinders of 32,000 pounds initial compression and tables of 1892.	

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Record of firing with 10-inch B. L. rifle, Woodbridge wire wound (steel),

[Object of firing.

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation or depression.	Instrumental velocity, 250 feet from muzzle.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs. Oz.*	*Inches.*	*Elevation.*	*Feet.*	*Pounds.*
Nov. 11	9	Du Pont's brown prismatic W. H., lot 4; density, 1.850. Received Nov. 3, 1886.	100 0 100 0	1,060 1,053	Cored shot, lot 537.	577 0	.....	37	1,737 Lost.	F, 30,600 G, 30,745
			200 0	7						
Nov. 13	10		115 0 115 0	1,219 1,212		577 0	.....	37	1,890 1,890	F, 36,000 G, 37,200
			230 0	7						
Nov. 13	11		115 0 125 0	1,270 1,317		578 0	.....	37	1,942 1,907	F, 38,933 G, 38,950
			240 0	7						
Nov. 13	12		121 0 125 0	1,280 1,317		577 0	.....	37	1,984 1,936	F, 39,400 G, 40,089
			246 0	7					175+1⅛°	
Nov. 28	13	Du Pont's brown prismatic W. H. lot, 4; density, 1.850.	134 0 134 0	1,420 1,415		578 8	245.3695	50	2,075 2,058	F, 47,756 G, 46,578
			268 0	7						

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at Sandy Hook Proving Ground, September 15 to November 28, 1893—Continued.

proof of powder.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Ft. In.*			
5 10	5 10	.....	Copper cylinders of 24,000 pounds initial compression and tables of 1890.	
5 11	5 11	.....	Great difficulty in seating shot.....	Gun mounted on 10-inch proof carriage. Two quarts of oil added to cylinder, filling it. Obturating friction primers. Fired into sand butt No. 1.
6 2	6 2	....	In loading, shot caught at junction of shot and powder chamber and could not be rammed home. It was removed; marks of rifling distinctly visible on forward portion of shot. Another shot loaded and the same difficulty. Seated after two trials.	Copper cylinders of 32,000 pounds initial compression and tables of 1892 used in rounds 10, 11, and 12. Velocities and pressures taken by Lieut. C. B. Wheeler, Ordnance Department. Firing conducted by the proof officer.
6 3	6 3	.....	The same difficulty as in previous round to seat projectile. Seated after two trials.	
			The recoil was too great for the strength of the piston rod and resulted in breaking the latter and permitting the gun and top carriage to recoil clear off the chassis. They dropped on the plank roadway in rear of the gun, breaking seven planks, and the rear of the carriage sunk into the sand about 2 feet, where it remains at this time, so that the damage to the top carriage can not be determined accurately. The injury seems to be slight. The elevating hand wheels are bent and a part of one tooth broken off one of the pinion wheels. The recoil marker is bent. The piston rod is broken through the last thread at the piston end. The rod is 3 inches in diameter and at the end was turned down to about 2⅜ inches and the thread cut on the turned down portion. The broken metal is about 2¼ inches in diameter. The rear transom of the chassis was struck by the top carriage in recoil and all the rivets and bolts holding it to the rails and the angle irons were broken. The transom itself is bent. The rear buffer was torn from the chassis and thrown about 45 feet to the rear. The gun in falling struck the rear end of the right chassis rail and opened a crack about $\frac{1}{4}$ inch between two rings of the outer layer of wire. The crack is 22$\frac{13}{16}$ inches from the front end of the first reinforce.	Gun mounted on 10-inch proof carriage. Obturating friction primer. Fired into sand butt No. 1. The shot was seated within 4 inches of the proper place by a rammer, and a battering ram was then used to force it the remaining distance. Copper cylinders of 40,000 pounds initial compression and tables of 1893. Firing conducted by First Lieut. M. F. Harmon, First U. S. Artillery.
.....	.....	.....		

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Record of firing with 10-inch B. L. rifle, Woodbridge wire wound

[Object of firing.

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Instrumental velocity, 263 to 263½ feet from muzzle.	Pressure per square inch of bore.
		Kind.	Weight.	No. of prisms.	Kind.	Weight.				
			Pounds.			*Pounds.*	*Inches.*		*Feet.*	*Pounds.*
Jan. 20	14	Du Pont's brown prismatic W. H., lot 3; density, 1.850. Received Dec. 8, 1893.	115 115 230	1,214 1,307+7	Solid shot rebanded.	575	245.507	16	1,911 1,911	P, 34,800 U, 35,500
Jan. 20	15		116 125 241	1,226 1,314+7		572	245.607	16	1,972 1,976	P, 36,400 U, 36,600
Jan. 20	16		121 130 251	1,277 1,367+7		567	245.407	16	2,030 2,032 188+150/2 and 188+151½/2	P, 39,855 U, 44,911

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(steel,) at Sandy Hook Proving Ground, January 20, 1894.

to prove powder.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Feet.*			
5 10	.....	Wind, calm; barometer, 30.67; thermometer, 26°; humidity, 48.	Console flew open at discharge. Copper cylinders of 24,000 pounds initial compression and tables of 1890.	Gun mounted on 10-inch proof carriage. Obturating friction primers. Fired to sea. Copper cylinders of 32,000 pounds initial compression and tables of 1892. In each case a pinch bar was used to raise base of projectile to prevent it being jammed at the beginning of the rifling. The charge of 251 pounds was calculated to give a pressure of 39,000 pounds per square inch from the data obtained by the previous round. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, assistant proof officer.
5 11	.. ....		A battering ram used to seat projectile.	
6 2	6		Right elevating hand wheel broken. Front clips bending down considerably.	

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Record of firing with 10-inch B. L. rifle, Woodbridge wire-wound

[Object of firing.

Date.	No. of fire	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Number stamped on base.	Travel of shot in bore.	Elevation.	Instrumental velocity, 250 feet from muzzle.	Pressure per square inch of bore.
			Lbs.			*Lbs.*		*Inches.*	°	*Feet.*	*Pounds.*
Mar. 20	17	Du Pont's brown prismatic W. H., lot 7. Received Mar. 17, 1894. Density, 1.860.	110 120 230	1, 174 1, 273	Shot rebanded.	575	2	245.407	40	Lost. 2.044	D, 37, 691 H, 47, 000
Mar. 20	18		120 110 230	1, 281 1, 166+7		575	1	245.507	40	2, 002 2, 015	D, 36, 917 H, 39, 367
Mar. 20	19		125 120 245	1, 333 1, 275+7		575	3	245.607	40	2, 102 2, 109	D, 43, 756 H (not reliable), 51, 175
Mar. 20	20		125 124 249	1, 333 1, 313+7		575	4	245.707	40	2, 088 2, 106	D, 51, 500 Q, 44, 360
Mar. 20	21		125 120 245	1, 335 1, 274+7		575	5	245.607	40	2, 085 2, 102	D, 42, 036 Q, 44, 420
										$175+\frac{13}{16}$	
		Du Pont's brown prismatic W. H., lot 8; density, 1.860. Received Apr. 16, 1894.			Solid shot, 502.						

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steel), at Sandy Hook Proving Ground, March 20 to April 24, 1894

o prove powder]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Ft. In.*			
5 10	5 10	Wind from rear 6 miles an hour; barometer, 30.38; thermometer, 54°; humidity, 30.	Copper cylinders of 24,000 pounds initial compression and tables of 1890 in Gauge D, and 28,000 pounds, copper, in Gauge H.	Gun mounted on 10-inch proof carriage. Obturating friction primers. Fired into sand butt No. 1.
5 10	5 10		Copper cylinders of 32,000 pounds initial compression and tables of 1892.	Copper cylinders of 4,000 pounds initial compression and tables of 1893 used in rounds 19 to 21, inclusive. The breech block was rotated with considerable difficulty in closing, probably due to nuts on rear of spindle being too tight
5 11	5 11		.....	The latch for holding the console back when the breech block is out is extremely inconvenient of access. The loading tray, which the peculiar shape of the forward end of the chamber in this gun makes necessary in order to be able to seat the projectile properly, is 79.825 inches long, and it projects into the gun 76.2 inches from the base of the breech.
6 0	6 0		.....	It weighs 84.5 pounds and requires two men to handle it. Moreover, extending as it does to the forward end of the powder chamber, it must be removed and a shot tray substituted before inserting the charge, since all of the latter, when seated, would rest on the long tray and be drawn out again with it.
6 0	6 0		.....	Firing conducted by Lieut. M. F. Harmon, First Artillery.
		Wind from right and rear, 30°, 12 miles an hour; barometer, 30.02; thermometer, 58°; humidity, 61.		Gun mounted on 10-inch proof carriage. Obturating friction primers. Fired into sand butt No. 1. After opening the breech block, and while the pressure gauges were being removed a slight sputtering noise attracted attention. An examination of the base of the breech led to the discovery of a very small quantity of what appeared to be powder residue oozing from the end of a joint between two segments. The residue was ejected explosively and forced small particles of metal from the edges of the joint. Scraping along this joint with a small blade of a pocket knife led to a second slight explosion, the liquid residue being thrown 2 feet or more to the rear, thus indicating considerable pressure. After the piece had been thoroughly cleaned a careful inspection showed its condition to be as follows: A crack (No. 1) in the tube, located about 5:30 o'clock, begins about 3 feet 4 inches from the base of the breech, and extends forward about 4 feet 6 inches nearly in a straight line; it then turns obliquely to the right, crosses 1 land, and about the middle of the adjacent groove separates into two irregular ring cracks, one extending to the right and the other to the left; the former crosses 4 grooves and 3 lands, and is about 4 inches long; the latter crosses 4 lands and 3 grooves, is of about the same length, and its continuity is interrupted once. This crack is apparently opened about $\frac{1}{16}$ inch at its widest part.

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Record of firing with 10-inch B. L. rifle, Woodbridge wire wound

[Object of firing.

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Number stamped on base.	Travel of shot in bore.	Elevation.	Instrumental velocity, 250 feet from muzzle.	Pressure per square inch of bore.
A. M.			*Lbs.*			*Lbs.*		*Inches.*	° ′	*Feet.*	*Pounds.*
Apr. 24	22	Du Pont's brown prismatic W. H., lot 8; density, 1.860. Received Apr. 16, 1894.	115 115 230	1,229 1,223+7	Solid shot, lot 502.	578	6	245.407	39	1,820 1,819	H, 32,600 P, less than 32,000
Apr. 24	23		125 120 245	1,335 1,328+7		578	7	245.707	39	1,920 1,923 175+$\frac{13}{16}$	H, 38,015 P, less than 40,000

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(*steel*), *at Sandy Hook Proving Ground, March 20 to April 24, 1894*—Continued.

to prove powder.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Ft. In.*			
2	6 2	Wind from right and rear, 30°, 12 miles an hour; barometer, 30.02; thermometer, 58°; humidity, 61.	Copper cylinders of 32,000 pounds initial compression and tables of 1892. Console flew open at discharge. Before this round the gas-check cup turned down; rear edge of cup 0.01 inch and front edge 0.005. Dowel pin in rotating handle repaired.	Another crack (No. 2) in the tube, located about 11 o'clock, begins about 3 feet 3 inches from the base of the breech and extends forward nearly in a straight line for about 4 feet 9 inches. At the point thus determined it turns at a right angle to the right, terminating in a ring crack, which crosses 5 grooves and 5 lands. This crack is opened to about the same extent as No. 1. What appears to be a very fine crack (No. 3), located about 4:30 o'clock, begins about 23 inches from the base of the breech and extends forward about 18 inches. Another fine crack (No. 4), located about 6:10 o'clock, begins about 3 feet 6 inches from the base of the breech and extends forward nearly in a straight line for about 2 feet 4 inches. Still another fine crack (No. 5), opened a little more than No. 4, located about 12:15 o'clock, begins about 3 feet 8 inches from the base of the breech and extends forward about 2½ feet. The foregoing cracks were located and measured by means of a pointed iron rod turned off at a right angle for about 4 inches at its forward end and used in the gun. The impressions show in addition a short crack 1½ inches long, located in the vicinity of 10 o'clock, and just at the beginning of the slope of the powder chamber. These cracks seem to be almost exactly in junction planes of staves. This is especially true of Nos. 1 and 2. Owing to the uniformity in the width and direction of the cracks it is difficult to match the impressions so as to measure the lengths of the former on the latter. No. 1 extends 19 inches and No. 2 extends 14⅛ inches into the rifling. The land which No. 1 crosses just after turning to the right and before separating, appears to be torn away from the surface of the bore on the muzzle side of the crack; it projects from the general surface of the bore enough to show quite a portion of the fractured surface in elevation as viewed from the breech. The impressions of the sharp angles formed by the junctions of the grooves with the driving edges of the lands present a uniformly hairy appearance, as though the rubber had been forced into very fine cracks and had torn when the forms were removed, a portion remaining in each crack. Cracks Nos. 1 and 2 follow two of these junctions from the beginning of the rifling, the former for 11⅛ inches, the latter for 14⅛ inches. Those portions of the impressions of these cracks within the rifling present the same hairy appearance shown by the other junctions, and are apparently no wider. The inference is that there are cracks at the other junctions also, but this can not be verified from the exterior of the gun with the means at hand. The gun shows little or no erosion in any part. Firing conducted by Lieut. M. F. Harmon, First Artillery.
5 4	6 4		Copper cylinders of 32,000 pounds initial compression in Gauge H, tables of 1892, and 40,000 pounds, copper, and tables of 1893 in Gauge P.	

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Star gauging of 10-inch B. L. rifle, Woodbridge wire-wound (steel), Sandy Hook Proving Ground.

LANDS.

[9.99845-inch ring and 10-inch points.]

From muzzle.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.	From muzzle.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
1	10.0015	10.0010	—.0005	170	10.0065	10.0105	.0040
5	10.0055	10.0050	—.0005	175	10.0070	10.0130	.0060
10	10.0065	10.0055	—.0010	180	10.0070	10.0130	.0060
15	10.0070	10.0055	—.0015	182	10.0070	10.0130	.0060
20	10.0075	10.0055	—.0020	184	10.0065	10.0130	.0065
25	10.0065	10.0055	—.0010	186	10.0065	10.0135	.0070
30	10.0060	10.0050	—.0010	188	10.0065	10.0135	.0070
35	10.0055	10.0055	.0000	190	10.0065	10.0145	.0080
40	10.0060	10.0055	—.0005	192	10.0065	10.0145	.0080
45	10.0055	10.0055	.0000	194	10.0065	10.0145	.0080
50	10.0055	10.0055	.0000	196	10.0065	10.0145	.0080
55	10.0050	10.0050	.0000	198	10.0065	10.0140	.0075
60	10.0050	10.0055	.0005	200	10.0070	10.0135	.0065
65	10.0045	10.0055	.0010	202	10.0065	10.0135	.0070
70	10.0045	10.0050	.0005	204	10.0070	10.0135	.0065
75	10.0050	10.0045	—.0005	206	10.0065	10.0145	.0080
80	10.0045	10.0045	.0000	208	10.0065	10.0150	.0085
85	10.0045	10.0045	.0000	210	10.0065	10.0155	.0090
90	10.0045	10.0045	.0000	212	10.0060	10.0160	.0100
95	10.0040	10.0045	.0005	214	10.0065	10.0160	.0095
100	10.0040	10.0045	.0005	216	10.0065	10.0165	.0100
105	10.0045	10.0035	—.0010	218	10.0060	10.0180	.0120
110	10.0045	10.0050	.0005	220	10.0060	10.0190	.0130
115	10.0045	10.0055	.0010	222	10.0055	10.0185	.0130
120	10.0045	10.0050	.0005	224	10.0060	10.0190	.0130
125	10.0045	10.0055	.0010	226	10.0055	10.0205	.0150
130	10.0055	10.0055	.0000	228	10.0055	10.0210	.0155
135	10.0055	10.0055	.0000	230	10.0060	10.0220	.0160
140	10.0055	10.0065	.0010	232	10.0060	10.0245	.0185
145	10.0055	10.0065	.0010	234	10.0055	10.0270	.0215
150	10.0055	10.0065	.0010	236	10.0055	10.0310	.0255
155	10.0060	10.0075	.0015	238	10.0055	10.0345	.0290
160	10.0065	10.0085	.0020	240	10.0060	10.0370	.0310
165	10.0065	10.0095	.0030	241	10.0060	10.0380	.0320

[9.5-inch points, with 0.2-inch washers, and set with 9.99845-inch ring, taken with one of the points on that portion of one of the lands which lies between the two forks of the crack designated in No. 1. There is a sort of a splinter here which is bent up toward the axis of the bore, the point being toward the rear.]

From muzzle.	After 23 rounds, May 3, 1894.	From muzzle.	After 23 rounds, May 3, 1894.
Inches.	*Inches.*	*Inches.*	*Inches.*
224	10.0205	229	9.9765
226	10.0215	230	9.9705
227	9.9905	231	9.9695
228	9.9835		

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GROOVES.

[9.99645-inch ring and 10-inch points.]

From muzzle.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.	From muzzle.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
1	10.1615	10.1600	—.0015	175	10.1635	10.1645	.0010
5	10.1640	10.1640	.0000	180	10.1635	10.1635	.0000
10	10.1625	10.1635	.0010	182	10.1635	10.1635	.0000
15	10.1635	10.1635	.0000	184	10.1635	10.1650	.0015
20	10.1635	10.1630	—.0005	186	10.1635	10.1645	.0010
25	10.1635	10.1635	.0000	188	10.1640	10.1650	.0010
30	10.1635	10.1625	—.0010	190	10.1645	10.1650	.0005
35	10.1635	10.1625	—.0010	192	10.1645	10.1660	.0015
40	10.1640	10.1635	—.0005	194	10.1645	10.1655	.0010
45	10.1640	10.1640	.0000	196	10.1650	10.1650	.0000
50	10.1640	10.1640	.0000	198	10.1645	10.1645	.0000
55	10.1640	10.1635	—.0005	200	10.1660	10.1640	—.0020
60	10.1645	10.1640	—.0005	202	10.1655	10.1640	—.0015
65	10.1640	10.1645	.0005	204	10.1665	10.1640	—.0025
70	10.1640	10.1640	.0000	206	10.1655	10.1640	—.0015
75	10.1635	10.1635	.0000	208	10.1665	10.1640	—.0025
80	10.1635	10.1630	—.0005	210	10.1665	10.1640	—.0025
85	10.1640	10.1635	—.0005	212	10.1665	10.1635	—.0030
90	10.1645	10.1630	—.0015	214	10.1665	10.1640	—.0025
95	10.1640	10.1625	—.0015	216	10.1660	10.1645	—.0015
100	10.1640	10.1620	—.0020	218	10.1660	10.1635	—.0025
105	10.1640	10.1625	—.0015	220	10.1660	10.1645	—.0015
110	10.1635	10.1635	.0000	222	10.1660	10.1650	—.0010
115	10.1640	10.1630	—.0010	224	10.1655	10.1660	.0005
120	10.1635	10.1625	—.0010	226	10.1670	10.1680	.0010
125	10.1635	10.1635	.0000	228	10.1660	10.1690	.0030
130	10.1635	10.1625	—.0010	230	10.1660	10.1705	.0045
135	10.1635	10.1620	—.0015	232	10.1660	10.1705	.0045
140	10.1635	10.1625	—.0010	234	10.1660	10.1705	.0045
145	10.1635	10.1630	—.0005	236	10.1660	10.1730	.0070
150	10.1635	10.1630	—.0005	238	10.1655	10.1750	.0095
155	10.1635	10.1630	—.0005	240	10.1655	10.1745	.0090
160	10.1635	10.1625	—.0010	241	10.1655	10.1730	.0075
165	10.1635	10.1625	—.0010	242	10.1655	10.1735	.0080
170	10.1635	10.1635	.0000				

After the piece had been thoroughly cleaned a careful inspection showed its condition to be as follows: A crack (No. 1) in the tube, located about 5:30 o'clock, begins about 3 feet 4 inches from the base of the breech and extends forward about 4 feet 6 inches, nearly in a straight line; it then turns obliquely to the right, crosses 1 land, and about the middle of the adjacent groove separates into two irregular ring cracks, one extending to the right and the other to the left; the former crosses 4 grooves and 3 lands, and is about 4 inches long; the latter crosses 4 lands and 3 grooves, is of about the same length, and its continuity is interrupted once. This crack is apparently opened about $\frac{1}{16}$ inch at its widest part. Another crack (No. 2) in the tube, located about 11 o'clock, begins about 3 feet 3 inches from the base of the breech and extends forward nearly in a straight line for about 4 feet 9 inches. At the point thus determined it turns at a right angle to the right, terminating in a ring crack, which crosses 5 grooves and 5 lands. This crack is opened to about the same extent as No. 1. What appears to be a very fine crack (No. 3), located about 4:30 o'clock, begins about 23 inches from the base of the breech and extends forward about 18 inches. Another fine crack (No. 4), located about 6:10 o'clock, begins about 3 feet 6 inches from the base of the breech and extends forward nearly in a straight line for about 2 feet 4 inches. Still another fine crack (No. 5), opened a little more than No. 4, located about 12:15 o'clock, begins about 3 feet 8 inches from the base of the breech and extends forward about 2½ feet. The foregoing cracks were located and measured by means of a pointed iron rod, turned off at a right angle for about 4 inches at its forward end, and used in the gun. The impressions show, in addition, a short crack, 1½ inches long, located in the vicinity of 10 o'clock, and just at the beginning of the slope of the powder chamber. These cracks seem to be almost exactly in the junction planes of staves. This is especially true of Nos. 1 and 2. Owing to the uniformity in the width and direction of the cracks, it is difficult to match the impressions so as to measure the lengths of the former on the latter.

No. 1 extends 19 inches and No. 2 extends 14½ inches into the rifling. The land which No. 1 crosses just after turning to the right, and before separating, appears to be torn away from the segments on the muzzle side of the crack; it projects from the general surface of the bore enough to show quite a portion of the fractured surface in elevation as viewed from the breech.

The impressions of the sharp angles formed by the junctions of the grooves with the driving edges of the lands present a uniformly hairy appearance, as though the rubber had been forced into very fine cracks and had torn when the forms were removed, a portion remaining in each crack. Cracks Nos. 1 and 2 follow two of these junctions from the beginning of the rifling, the former for 11½ inches, the latter for 14½ inches. Those portions of the impressions of these cracks within the rifling present the same hairy appearance shown by the other junctions, and are apparently no wider. The inference is that there are cracks at the other junctions also, but this can not be verified from the exterior of the gun with the means at hand. The gun shows little or no erosion in any part. (Extract from firing record, after 23 rounds, April 24, 1894.)

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CHAMBER, VERTICAL.

[12.4-inch ring and points.]

From breech.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.	From breech.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
19	12.5645	12.5850	.0205	46	12.5000	12.5050	.0050
20	12.5000	12.5260	.0260	47	12.5000	12.5040	.0040
21	12.5000	12.5210	.0210	48	12.5000	12.5050	.0050
22	12.5000	12.5125	.0125	49	12.5000	12.5040	.0040
23	12.5005	12.5075	.0070	50	12.5000	12.5050	.0050
24	12.5000	12.5055	.0055	51	12.5000	12.5050	.0050
25	12.5000	12.5045	.0045	52	12.5000	12.5050	.0050
26	12.5005	12.5030	.0025	53	12.5000	12.5060	.0060
27	12.5000	12.5025	.0025	54	12.5000	12.5055	.0055
28	12.5000	12.5025	.0025	55	12.5000	12.5050	.0050
29	12.5000	12.5020	.0020	56	12.5000	12.5060	.0060
30	12.5000	12.5020	.0020	57	12.5000	12.5050	.0050
31	12.5005	12.5020	.0015	58	12.5000	12.5060	.0060
32	12.5005	12.5030	.0025	59	12.5000	12.5060	.0060
33	12.5005	12.5025	.0020	60	12.5000	12.5060	.0060
34	12.5005	12.5030	.0025	61	12.5000	12.5060	.0060
35	12.5000	12.5025	.0025	62	12.5000	12.5065	.0065
36	12.5005	12.5025	.0020	63	12.5000	12.5065	.0065
37	12.5000	12.5035	.0035	64	12.5000	12.5065	.0065
38	12.5000	12.5030	.0030	65	12.5000	12.5075	.0075
39	12.5000	12.5035	.0035	66	12.5000	12.5080	.0080
40	12.5000	12.5045	.0045	67	12.5000	12.5070	.0070
41	12.5000	12.5045	.0045	68	12.5000	12.5075	.0075
42	12.5000	12.5040	.0040	69	12.5000	12.5075	.0075
43	12.5000	12.5050	.0050	70	12.4900	12.4975	.0075
44	12.5005	12.5055	.0050	71	12.4330	12.4390	.0060
45	12.5000	12.5055	.0055				

CHAMBER, HORIZONTAL.

[12.4-inch ring and points.]

From breech.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.	From breech.	Before firing, Aug. 14, 1893.	After firing 23 rounds, May 3, 1894.	Increase.
Inches.	*Inches.*	*Inches.*	*Inch.*	*Inches.*	*Inches.*	*Inches.*	*Inch.*
19	12.5730	12.5935	.0205	46	12.5000	12.5025	.0025
20	12.5000	12.5275	.0275	47	12.5000	12.5025	.0025
21	12.5000	12.5220	.0220	48	12.5000	12.5025	.0025
22	12.5000	12.5140	.0140	49	12.5000	12.5025	.0025
23	12.5000	12.5080	.0080	50	12.5000	12.5030	.0030
24	12.5000	12.5065	.0065	51	12.5000	12.5025	.0025
25	12.5000	12.5060	.0060	52	12.5000	12.5030	.0030
26	12.5000	12.5050	.0050	53	12.5000	12.5030	.0030
27	12.5000	12.5045	.0045	54	12.5000	12.5035	.0035
28	12.5000	12.5045	.0045	55	12.5000	12.5030	.0030
29	12.5000	12.5040	.0040	56	12.5000	12.5020	.0020
30	12.5000	12.5040	.0040	57	12.5000	12.5020	.0020
31	12.5000	12.5045	.0045	58	12.5000	12.5015	.0015
32	12.5000	12.5040	.0040	59	12.5000	12.5015	.0015
33	12.5000	12.5040	.0040	60	12.5000	12.5020	.0020
34	12.5000	12.5035	.0035	61	12.5000	12.5010	.0010
35	12.5000	12.5040	.0040	62	12.5000	12.5010	.0010
36	12.5000	12.5040	.0040	63	12.5000	12.5005	.0005
37	12.5000	12.5035	.0035	64	12.5000	12.5000	.0000
38	12.5000	12.5030	.0030	65	12.5005	12.5000	—.0005
39	12.5005	12.5035	.0030	66	12.5000	12.5010	.0010
40	12.5000	12.5030	.0030	67	12.5005	12.5010	.0005
41	12.5000	12.5030	.0030	68	12.5000	12.5010	.0010
42	12.5000	12.5030	.0030	69	12.5005	12.4990	—.0015
43	12.5000	12.5030	.0030	70	12.4910	12.4910	.0000
44	12.5000	12.5025	.0025	71	12.4340	12.4340	.0000
45	12.5000	12.5030	.0030				

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APPENDIX 21.

REPORT OF FIRINGS WITH 12-INCH B. L. MORTARS TO DETERMINE PITCH OF RIFLING.

(6 plates.)

SANDY HOOK PROVING GROUND,
(*P. O. Box 1449*) *New York, N. Y., February 7, 1894.*

SIR: I have the honor to forward herewith record of firings, made in compliance with your instructions of November 23, 1893, with the 12-inch B. L. mortar, cast iron hooped, and the 12-inch B. L. mortar, steel, for the purpose of ascertaining which twist of rifling gives the best results as to accuracy and stability of flight.

Targets were taken at about 2,400 yards with both cast iron and steel mortars, the charges being so regulated as to give the same velocity, 538 foot seconds, with each mortar to a projectile weighing 1,010 pounds. The projectiles being all above standard weight they were so selected as to weigh as nearly as possible the same, respectively, in lots of five fired from the two mortars. It would have been better had a weight of, say, 1,010 pounds been selected and all projectiles brought up to this weight. The targets made are forwarded herewith. They show that with either mortar 4 shots out of 5 would have hit a vessel of the size of the *Philadelphia* when "head on." When "broadside on," 3 out of 5 with the cast-iron mortar and 2 out of 5 of the steel mortar would have taken effect. The target with the cast-iron mortar was superior to that with the steel mortar, but the latter was somewhat affected by the wind. It will be noted also that the position of the axes of the projectiles at the instant of striking the ground was more advantageous with the cast-iron than with the steel mortar. The firings of December 9 with 800-pound projectiles were made inadvertently, and it was thought best to repeat these firings with the steel mortar on the 12th of December, 1893.

Firings at long range were made with the cast-iron mortar only when your instructions of January 5 were received modifying those of November 23, 1893, by requiring a cast-iron hooped mortar to be mounted on the original Easton & Anderson carriage, and that the targets be made by firing each piece alternately, round by round. The projectiles were also to be made of same weight. While the mortar was being mounted on this carriage firings were made to determine a charge to give 1,020 foot seconds velocity in a cast-iron hooped mortar. This charge was found to be 76 pounds 8 ounces. By calculation from considerable data available from previous firings the charge to give same velocity in the steel mortar was found to be 84 pounds. After many delays, due to inclement weather, firings were begun on the 2d instant, and one round was fired from each mortar. At this round the original Easton &

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Anderson carriage was rendered entirely unserviceable, as described in detail in the record. The breaking of this carriage is due to the fact that a sufficient length of recoil was not permitted by its construction. It had undoubtedly been overstrained in previous firings. It can not be repaired without renewing almost the entire top portion of the carriage. In order that the firings may be continued it will be necessary to provide another carriage. This can be done by assembling one of the carriages manufactured by R. Poole & Son Co., on hand, available for this purpose, on the platform plate intended for 12-inch barbette carriage, which platform is not now in use. It is thought the work can be done and firings made without materially delaying the test of the 12-inch barbette carriage, which has not yet arrived at this post.

Instructions are respectfully requested.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

[First indorsement.]

ORDNANCE OFFICE, *Washington, February 20, 1894.*

Respectfully returned to the commanding officer, Sandy Hook Proving Ground, in connection with telegram of 9th instant, directing a new mortar carriage to be used in completing these firings, as suggested with n.

With the object of obtaining data to verify range tables he will make firings with each mortar to determine the velocity with the charges and weights of the projectiles used for making the targets.

He is requested, also, to accompany his report with drawings of the 800 and 1,000 pound projectiles used in the firings.

By order of the Chief of Ordnance:

R. BIRNIE,
Captain, Ordnance Department, U. S. Army.

[Second indorsement.]

SANDY HOOK PROVING GROUND, *April 24, 1894.*

Respectfully returned to the Chief of Ordnance, U. S. Army, with record of firings required by preceding indorsement. In order to insure the same atmospheric conditions in making the targets from the two mortars they were fired alternately and as nearly simultaneously as possible. The interval between the shots was about one minute for the short range and two minutes for the long range. The charges were proportioned so as to give the same velocity with the two mortars. This velocity was 554 foot seconds for the short range and 1,020 foot seconds for the long range. The weights of the projectiles were made the same for each range, respectively, this weight being the same as that used in the firings for determining the charge. Great care was taken in conducting the firings, and it is believed that the results represent the comparative merits of the two mortars. They are believed to be very satisfactory for each, but slightly more so, especially as to lateral dispersion, for the cast-iron steel-hooped mortar than for the steel mortar. Records contain drawings of projectiles.

FRANK HEATH,
Captain, Ordnance Department, U. S. Army, Commanding.

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Record of firing with 12-inch B. L. rifled mortar (steel), No. 1, Watervliet

[Object of firing, to obtain velocities in connection with firing

Date.	No. of fire.	Powder. Kind.	Weight.	No. of prisms.	Projectile. Kind.	Weight.	Number stamped on base.	Travel of shot in bore.	Elevation	Instrumental velocity.
			Lbs. Oz.			*Pounds.*		*Inches.*	° ′	*Feet.*
A. M.										*175 ft. from muzzle.*
Mar. 8	160	Du Pont's brown prismatic V. M., lot 6; density, 1.830.	82 1	873+7	Rebanded	811	37	98.125	0 29	986 991
Mar. 8	161		85 12	914+7	Shell, lot 485; 3¼ calibers long; band, 1¼ inches wide, 1½ inches from base.	811	38	98.125	0 29	1,029 Lost.
Mar. 8	162		84 1½	897+7		811	39	98.125	0 29	1,030 1,028
Mar. 8	163		82 7½	882+7		811	40	98.125	0 15	1,011 1,015
Mar. 8	164		82 14½	889+7	Rebanded	811	41	98.125	0 10	1,010 1,000
Mar. 8	165		83 1½	888+7	Shell, lot 485; 3¼ calibers long; band, 1¼ inches wide, 1½ inches from base.	811	42	98.125	0 10	1,009 1,012
Mar. 8	166		83 1½	888+7		811	43	98.125	0 10	1,030 1,028
Mar. 8	167		82 8	878+7		811	44	98.125	0 10	1,010 1,012
										$125+\frac{100}{2}$
Mar. 9	168		82 12	883+7	Shell, lot 485; 3¼ calibers long; band, 1¼ inches wide, 1½ inches from base.	811	45	98.125	0 10	Lost.
										$125+\frac{100}{2}$
										204 ft. from muzzle.
Mar. 9	169	Du Pont's hexagonal M. W.; density, 1.725; granulation, 72.	32 6	.....	Rebanded 4½ calibers long; band, 1¼ inches wide, 1½ inches from base.	1,014	46	98.225	1 10	558 Lost
Mar. 9	170		31 14	.....		1,014	47	98.225	1 18	551 Lost
Mar. 9	171		32 1	.....		1,014	48	98.225	1 18	551 Lost.
										$179+\frac{50}{2}$
										175 ft. from muzzle.
Mar. 9	172	Du Pont's brown prismatic V. M., lot 6; density, 1.830.	82 10	883+7	Shell, lot 485; 3¼ calibers long; band, 1¼ inches wide, 1½ inches from base.	811	49	98.225	10	1,031 1,016

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Arsenal, at Sandy Hook Proving Ground, March 8 and 9, 1894.

to obtain comparative targets with steel and cast-iron mortars.]

Pressure per square inch of bore.	Recoil.		Counter recoil.		Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.	*Ft.*	*In.*	*Ft.*	*In.*			
D, 21,277 H, less than 24,000	5	5½	4	10½	Wind from left, 90°, 3 miles an hour; barometer, 30.12; thermometer, 46°; humidity, 53.	Copper cylinders of 18,000 pounds initial compression and tables of 1892 used in Gauge D, and 24,000 pounds, copper, and tables of 1890 in Gauge H.	
D, 23,292 H, 23,633	5	5	4	8		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
D, 23,700 H, 23,733	5	5	4	8		Copper cylinders of 18,000 pounds initial compression and tables of 1892. Shell came out of butt and fell to the rear.	
D, 22,671 H, 23,000	5	5½	4	11		Copper cylinders of 18,000 pounds initial compression and tables of 1892. Shell came out of butt and fell about 75 yards to the right.	
D, 21,920 H, 22,233	5	5½	4	10		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
D, 22,300 H, 22,333	5	5½	5	0		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
D, 23,625 H, 23,200	5	5½	5	2		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
D, 22,133 H, 22,150	5	6	5	1		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	Mortar mounted on proof carriage (Krupp). Obturating friction primers. Before round No. 160 new bolt was put through right fork holding piston. Fired into sand butt No. 2. Carriage 3 inches out of battery. Firing conducted by Lieut. M. F. Harmon, First Artillery, U. S. Army.
D, 23,055 H, 22,771	5	6	5	2½	Wind from left, 45°; humidity, 68.	Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
D, 12,060 H, less than 14,000	4	7	4	7	Wind from left, 90°, 6 miles an hour; barometer, 30.24; thermometer, 45°;	Copper cylinders of 9,000 pounds initial compression and tables of 1892 used in Gauge D, and 14,000 pounds, copper, and tables of 1892 in Gauge H.	
D, 6,735 H, 6,560	4	6	4	6		Copper cylinders of 9,000 pounds initial compression and tables of 1892.	
D, 7,166 H, 5,307	4	6	4	6		Copper cylinders of 9,000 pounds initial compression and tables of 1892.	
D, 23,246 H, 21,114	5	6	5	6		Copper cylinders of 18,000 pounds initial compression and tables of 1892.	

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Record of firing with 12-inch B. L. mortar (steel), No. 1, Watervliet

[Object of firing, to obtain target in comparison with target

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Number on base.	Travel of shot in bore.	Elevation.	Time of flight.	Pressure per square inch of bore.
A. M.			*Lbs. Oz.*			*Pounds.*			°	"	*Pounds.*
Apr. 3	178	Du Pont's hexagonal M. W.; density, 1.725; granulation, 72.	32 0	.....	Shell, rebanded, 3.86 calibers long; band, 1⅛ inches from base, 1¼ inches wide.	1,014	8	98.275	60	Lost.	{ D, 11,950 { H, 11,850
Apr. 3	179		32 0	.....		1,014	6	98.275	60	Lost.	{ D, 11,750 { H, 11,750
Apr. 3	180		32 0	.....		1,014	10	98.275	60	Lost.	{ D, 11,500 { H, 11,600
Apr. 3	181		32 0	.....		1,014	12	98.275	60	Lost.	{ D, 11,450 { H, 11,500
Apr. 3	182		32 0	.....		1,014	14	98.275	60	Lost.	{ D, 11,600 { H, 11,670

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Arsenal, at Sandy Hook Proving Ground, April 5 and 7, 1894.

made simultaneously from 12-inch B. L. cast-iron mortar.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.						General remarks.
			TARGET.						
			Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. −	Lateral. Right.	Lateral. Left.	
Ins.	*Ins.*		Yds.	Yds.	Yds.	Yds.	Yds.	Yds.	
11½	11	Wind from right and rear, 85°, 2 miles an hour.	2,468	176	3.6	.....	.....	16.2	Mortar mounted on spring return carriage No. 2. R. Poole & Son Co.
13	13	Wind from right and rear, 85°, 4 miles an hour.	2,466	185	1.6	.....	.....	7.2	Obturating friction primers.
14½	14½	Wind from left and rear, 20°, 4 miles an hour.	2,460	197	.....	4.4	4.8	.....	Fired down the beach.
14	14	Wind from left, 90°, 4 miles an hour.	2,465	200	.6	.....	7.8	.....	Copper cylinders of 9,000 pounds initial compression and tables of 1890.
14	14	Wind from left, 90°, 6 miles an hour.	2,463	203	.....	1.4	10.8	.....	The charge is taken from previous firing and gives ·554 foot seconds.
			.....	.....	5.8	5.8	23.4	23.4	Each round followed a round from the cast-iron mortar as soon as the time of flight for the latter was observed, the interval being about one minute.

12,322 ÷ 5 = 2,464.4; 961 ÷ 5 = 192.2; 11.6 ÷ 5 = 2.32; 46.8 ÷ 5 = 9.36.

	Yards.
Greatest range	2,468
Least range	2,460
Dispersion in range	8
Greatest deviation from plane of fire	203
Least deviation from plane of fire	176
Lateral dispersion	27
Mean range	2,464.4
Mean lateral deviation from plane of fire	192.2
Mean longitudinal deviation from center of impact	2.32
Mean lateral deviation from center of impact	9.36
Mean absolute deviation from center of impact	9.64

Mean angular deviation from plane of fire, 4°, 28′, 30″.

The piece was aimed by a brass pointer attached to lower roller path and a vertical line on a brass plate attached to upper roller path.

Barometer, 30.51; thermometer, dry, 39°; thermometer, wet, 32°; humidity, 43.

Firing conducted by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with 12-inch B. L. mortar (steel), No. 1, Watervl

[Object of firing, to obtain target in comparison with tar

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Number on base.	Travel of shot in bore.	Elevation.	Time of flight.	Pressure per square inch of bore.
A. M.			*Lbs. Oz.*			*Pounds.*			°	″	*Pounds*
Apr. 7	183	Du Pont's brown prismatic V. M., lot 6; density, 1.830.	82 12	877—7	Shell, lot 485; 3¼ calibers long; band, 1¼ inches from base, 1¼ inches wide.	811	.....	98.425	60	Lost.	D, less than 24,000. H, less than 24,000.
Apr. 7	184		82 12	878—7		811	.....	98.425	60	Lost.	D, less than 24,000. H, less than 24,000.
Apr. 7	185		82 12	878—7		811	.....	98.425	60	53¼	D, less than 24,000. H, less than 24,000.
Apr. 7	186		82 12	878—7		811	.....	98.425	60	53¼	D, less than 24,000. H, less than 24,000.
Apr. 7	187		82 12	878—7		811	.....	98.425	60	53	D, 19,200. H, 21,990.
Apr. 7	188		82 12	878—7		811	.....	98.425	60	53	D, 22,970. H, 18,150.
Apr. 7	189		82 12	878—7		811	.....	98.425	60	53	D, 19,440 H, 21,900.

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Arsenal, at Sandy Hook Proving Ground, April 3 and 7, 1894—Continued.

made simultaneously from 12-inch B. L. cast-iron mortar.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ins.	*Ins.*			
17	17			
17½	17½			

TARGET.

Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. −	Lateral. Right.	Lateral. Left.
Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
7,387	508	41	.....	.....	31.2
7,284	563	.....	62	23.8	.....
7,291	557	.....	55	17.8	.....
7,403	538	57	.....	.....	1.2
7,365	530	19	.....	.....	9.2
.....	.....	117	117	41.6	41.6

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
17½	17½	Wind from left and front, 15°, 9 miles an hour.		Mortar mounted on spring return carriage No. 2. R. Poole & Son Co. Obturating friction primers. Fired to sea. For rounds 187 to 189 copper cylinders of 18,000 pounds initial compression and tables of 1892. The charge is taken from previous firing and gives 1,020 foot seconds. Each round, except 183 and 184, was followed by a round from the cast-iron mortar as soon as the records were obtained at the plane tables, the interval being about two minutes. The shells from rounds 183 and 184 are supposed to have fallen behind the mile target and could not be observed. The piece was aimed by a brass pointer attached to lower roller path and a vertical line on a brass plate attached to upper roller path. Barometer, 30.31; thermometer, dry, 43°; thermometer, wet, 35°; humidity, 41. Observed at plane table at Navesink Highlands by Lieut. M. F. Harmon, First Artillery, and on the fort wall by Mr. Richard Shorrock. Firing conducted by Lieut. F. P. Peck, Ordnance Department.
17½	17½	....do		
17½	17½	Wind from left and front, 5°, 9 miles an hour.		
17½	17½	Wind from left and front, 5°, 10 miles an hour.		
17½	17½	....do		

36,730 + 5 = 7,346; 2,696 + 5 = 539.2; 234 + 5 = 46.8; 83.2 + 5 = 16.64.

	Yards.
Greatest range	7,403
Least range	7,284
Dispersion in range	119
Greatest deviation from plane of fire	563
Least deviation from plane of fire	508
Lateral dispersion	55
Mean range	7,346
Mean lateral deviation from plane of fire	539.2
Mean longitudinal deviation from center of impact	46.8
Mean lateral deviation from center of impact	16.64
Mean absolute deviation from center of impact	49.67

Mean angular deviation from plane of fire, 4° 12′ 30″.

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Record of firing with 12-inch B. L. cast-iron mortar, No. 51, Builders

[Object of firing.

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Wgt.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Gauges.	Recoil.	Counter recoil.
A. M.			*Lbs. Oz.*			*Lbs.*	*Inches.*	°	*Lbs.*		*Ins.*	*Inches*
Dec. 1	1	Du Pont's hexagonal M. W.; density, 1.725; granulation, 72.	27 9	.....	Lot 546	1,004	91.5	60	.....	.....	10⅜	8½
Dec. 7	9		27 9	.....	Lot 485	806	91.5	60	.....	.....	12⅝	12
Dec. 7	10		27 9	.....		803	91.5	60	.....	.....	12⅛	12⅛
Dec. 7	11		27 9	.....	Lot 546	1,003	91.5	60	13,300 / 11,700	F / G	13⅛	13⅛
Dec. 7	12		27 9	.....		1,002	91.5	60	13,000 / 12,000	F / G	13⅛	13⅛
Dec. 7	13		27 9	.....		995	91.5	60	12,600 / 11,900	F / G	13⅛	13⅛
Dec. 7	14		27 9	.....		1,000	91.5	60	13,020 / 12,750	F / G	13⅛	13⅛
Dec. 7	15		27 9	.....	Rebanded.	1,011	91.5	60	13,100 / 12,600	F / G	13⅛	13⅛

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Iron Foundry, at Sandy Hook Proving Ground, December 1 to 8, 1893.

to obtain targets.]

Wind. strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.

Range.	Deviation, right of plane of fire.	Observed time of flight.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Humidity.
Yards.	*Yards.*	*Seconds.*				
2,334	109	30	29.90	41	44	78
2,757	186	Lost.	30.38	35	36	91
2,797	191	Lost.	30.38	35	36	91
2,365	145	30	30.38	36	38	83
2,353	139	30½	30.38	36	38	83
2,337	146	30	30.39	37	39	83
2,365	145	29½	30.39	37	39	83
2,345	137	29½	30.39	37	39	83

Dec. 1, wind from right and rear, 80°, 12 miles an hour. Dec. 7, wind calm.

Round 15 was found by computation from data of previous firing, and should give a velocity of 538 foot seconds to a projectile of 1,010 pounds.

Mortar mounted on spring return carriage No. 2. R. Poole & Son Co.
Obturating friction primers.
Fired down the beach.
Mortar aimed by wooden bore sights.
The carriage traverses with great ease, requiring not more than an application of about 10 pounds to one handle.
With the 800-pound projectiles during the last moments of flight the point was well to the front, base toward the gun, and they struck ground in this position.
With the 1,000-pound projectiles the axis was inclined slightly forward, base to front, but became vertical just before striking the ground.
Firing conducted by Lieut. F. P. Peck, Ordnance Department.
Fall of projectiles noted by Capt. Frank Heath, Ordnance Department.

TARGET.

No. of round.	Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. −	Lateral. Right.	Lateral. Left.
	Yards.	*Yards.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
11	2,365	145	12	.....	2.6	.....
12	2,353	139	.....	.....	.....	3.4
13	2,337	146	.....	16	3.6	.....
14	2,365	145	12	.....	2.6	.....
15	2,345	137	.....	8	.....	5.4
	.....	.....	24	24	8.8	8.8

11,765 ÷ 5 = 2,353; 712 ÷ 5 = 142.4;
48 ÷ 5 = 9.6; 17.6 ÷ 5 = 3.52.

	Yards.
Greatest range	2,365
Least range	2,337
Dispersion in range	28
Greatest deviation from plane of fire	146
Least deviation from plane of fire	137
Lateral dispersion	9
Mean range	2,353
Mean lateral deviation from plane of fire	142.4
Mean longitudinal deviation from center of impact	9.6
Mean lateral deviation from center of impact	3.52
Mean absolute deviation from center of impact	10.22

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Record of firing with 12-inch B. L. cast-iron mortar, No 51, Builders Iron

[Object of firing.

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Gauges.	Recoil.	Counter recoil.
		Kind.	Weight.	No. of prisms.	Kind.	Wgt.						
A. M.			*Lbs.* *Oz.*			*Lbs.*	*Inches.*	°	*Lbs.*		*Ins.*	*Inches.*
Dec. 7	16	Du Pont's brown prismatic V. M., lot 7; density, 1.835.	67 5	712+7	Shell, lot 485; 3¼ calibers long.	812	91.5	60	21,400	F	16½	16½
									21,000	G		
P. M.												
Dec. 8	17		77 4	818+7		805	91.5	60	25,500	F	17	17
									27,000	G		
Dec. 8	18		77 4	818+7		811	91.5	60	26,400	F	17	17
									27,800	G		
Dec. 8	19		77 4	820+7		805	91.5	60	27,800	F	17	17 5/16
									27,800	G		
Dec. 8	20		77 4	820+7		812½	91.5	60	28,000	F	17 5/16	17 5/16
									28,100	G		
Dec. 8	21		77 4	819+7		804	91.5	60	28,000	F	17⅜	17⅜
									27,700	G		
Dec. 8	22		77 4	820+7		808	91.5	60	28,500	F	17	17
									28,300	G		

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Foundry, at Sandy Hook Proving Ground, December 1 to 8, 1893—Continued.

to obtain targets:]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	Range.	Deviation, right of plane of fire.	Observed time of flight.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Humidity.	General remarks.
		Yards.	*Yards.*	*Seconds.*					Mortar mounted on spring return carriage No. 2. R. Poole & Son Co.
Calm ..		Lost.	Lost.	50	30.36	38	40	84	Obturating friction primers.
Calm ..		Lost.	Lost.	52.5	30.53	34	37	74	Fired to sea.
Calm ..		7,662	428	52.5	30.52	34	37	74	Aimed by wooden bore sights over right edge of 1,000 yards target.
Calm ..		7,648	428	52.5	30.52	34	37	74	Copper cylinders of 24,000 pounds initial compression and tables of 1890.
Calm ..		7,608	425	52.5	30.52	34	37	74	Firing conducted by Lieut. F. P. Peck, Ordnance Department.
Calm ..		7,629	427	52.5	30.52	34	37	74	
Calm ..		7,683	409	53	30.52	34	37	74	

A part of round 22 was taken from the magazine about a week after the other.

TARGET.

No. of round.	Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. −	Lateral. Right.	Lateral. Left.
	Yards.	*Yards.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*
18	7,662	428	16	.....	4.6	.....
19.....	7,648	428	2	.....	4.6	.....
20.....	7,608	425	.....	38	1.6	.....
21.....	7,629	427	.....	17	3.6	.....
22.....	7,683	409	37	.....	.....	14.4

38,230 ÷ 5 = 7,646; 2,117 ÷ 5 = 423.4;
110 ÷ 5 = 22; 28.8 ÷ 5 = 5.76.

	Yards.
Greatest range.....	7,683
Least range.....	7,608
Dispersion in range.....	75
Greatest deviation from plane of fire.....	428
Least deviation from plane of fire	409
Lateral dispersion	19
Mean range.....	7,646
Mean lateral deviation from plane of fire	423.4
Mean longitudinal deviation from center of impact	22
Mean lateral deviation from center of impact	5.76
Mean absolute deviation from center of impact	22.74

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Record of firing with 12-inch B. L. mortar (steel), No. 1, Water-

[Object of firing.

	No. of fire.	Powder. Kind.	Powder. Wgt.	Projectile. Kind.	Projectile. Weight.	Elevation.	Pressure per square inch of bore.	Gauge.	Recoil.	Counter recoil.	Wind, strength and direction.
			Lbs.		*Lbs. Oz.*	°	*Pounds.*		*Ins.*	*Ins.*	
A. M.	140	Du Pont's hexagonal, M. W. density 1.725; granulation, 72.	31	Shell, lot 485.	803 8	60	11,500	M	12¾	12¾	Wind from right and rear— 50°, 12 miles per hour.
							11,700	N			
	141		31		807 0	60	11,500	M	13	13	70°, 23 miles per hour.
							11,700	N			
	142		31		1,003 0	60	11,800	M	13¾	13¾	70°, 18 miles per hour.
							Less than 14,000	N			
	143		31		1,003 0	60	11,500	M	13¾	13¾	70°, 13 miles per hour.
							11,400	N			
	144		31		1,000 0	60	11,500	M	15	15	70°, 13 miles per hour.
							11,150	N			
	145		31		1,005 0	60	10,750	M	15	15	70°, 12 miles per hour.
							11,500	N			
	146		31		1,011 0	60	.....	.....	14⅛	15	60°, 10 miles per hour.

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vliet Arsenal, at Sandy Hook Proving Ground, December 12, 1893.

to obtain targets.]

Range.	Deviation, right of plane of fire.	Observed time of flight.	Barometer.	Thermometer. Wet.	Thermometer. Dry.	Humidity.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.
Yards.	*Yards.*	*Seconds.*					
2,837	159	34	30.11	42	43	92	Mortar mounted on spring return carriage No. 2. R. Poole & Son Co.
2,892	156	34	30.11	42	43	92	Obturating friction primers.
2,414	99	30	30.09	41	44	78	Fired down the beach.
2,466	69	30¼	30.07	42	45	78	Mortar aimed by wooden bore sights.
2,437	90	30¼	30.07	42	45	78	With the 800-pound projectiles, during last moments of flight, axis was inclined slightly forward, base to front; it became vertical just before striking the ground.
2,439	86	30¼	30.07	42	45	78	With the 1,000-pound projectiles the axis was inclined forward, base to front, and was in this position when the shell struck the ground.
2,404	96	30	30.07	42	45	78	Firing conducted by Lieut. F. P. Peck, Ordnance Department.
							Fall of projectiles observed by Capt. Frank Heath, Ordnance Department.

Round 145 gave a velocity of 538 foot seconds to a projectile of 1,010 pounds, Sept. 18, 1893.

TARGET.

No. of round.	Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. —	Lateral. Right.	Lateral. Left.
	Yards.	*Yards.*	*Yds.*	*Yds.*	*Yards.*	*Yards.*
142	2,414	99	.....	18	11	.....
143	2,466	69	34	.....	.....	19
144	2,437	90	5	.....	2	.....
145	2,439	86	7	.....	.....	2
146	2,404	96	.....	28	8	.....
.....	.....	.....	46	46	21	21

12,160 ÷ 5 = 2,432; 440 ÷ 5 = 88; 92 ÷ 5 = 18.4; 42 ÷ 5 = 8.4

General remarks.

	Yards.
Greatest range	2,466
Least range	2,404
Dispersion in range	62
Greatest deviation from plane of fire	99
Least deviation from plane of fire	69
Lateral dispersion	30
Mean range	2,432
Mean lateral deviation from plane of fire	88
Mean longitudinal deviation from center of impact	18.4
Mean lateral deviation from center of impact	8.4
Mean absolute deviation from center of impact	20.2

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Record of firing with 12-inch B. L. cast-iron mortar, No. 57, Build

[Object of firing, to obtain velocities in connection with firing

	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Instrumental velocity 225 feet from muzzle.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs.*	*Inches.*	° ′	*Feet.*	*Pounds.*
A. M....	3	Du Pont's brown prismatic, V. M., lot 7; density, 1.835.	76 10½	814 +7	Shell rebanded.	811	91.460	0 00	1020 1018	D, 26,967 H, 26,883
	4		76 5½	808½+7		811	91.660	0 00	1009 1013	D, 27,000 H, 24,859
	5		76 8	810 +7		811	91.710	0 00	1018 1013	D, 27,218 H, 26,218
									175+$\frac{19}{32}$	

Record of firing with 12-inch B. L. mortar (steel), No. 1, Water-

[Object of firing, to obtain target in comparison with

	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs.*	*Inches.*	°	*Pounds.*
A. M	158	Du Pont's brown prismatic V. M., lot 6; density, 1.830.	81 8	906+7	Mortar shell, lot 485; 3¼ calibers long; band, 1¼ inches from base.	811	98.255	00	P, less than 24,000. U, less than 24,000.

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ere Iron Foundry, at Sandy Hook Proving Ground, January 24, 1894.

to obtain comparative targets with steel and cast-iron mortars.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. in.	*Ft. in.*			
4 10	4 7	Wind from right and front 30°, 19 miles an hour.	Shell stamped No. 21 on base plug. Carriage 7 inches out of battery when mortar was fired.	Mortar mounted on proof carriage (Krupp). Obturating friction primers. Fired into sand butt No. 2. Copper cylinders of 24,000 pounds initial compression and tables of 1890. Barometer, 30.26; thermometer, 52°; humidity, 100. Velocities taken by Lieut. F. P. Peck, Ordnance Department. Firing conducted by Lieut. M. F. Harmon, First Artillery.
4 10	4 0		Shell stamped No. 22 on base plug. Carriage 10 inches out of battery when mortar was fired.	
4 11	4 10		Shell stamped No. 23 on base plug. Carriage 10 inches out of battery when mortar was fired. Shell came out of butt and fell to the right.	

vliet Arsenal, at Sandy Hook Proving Ground, February 2, 1894.

target made simultaneously from 12-inch cast-iron mortar.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Feet.	*Feet.*			
17	17	Wind from right and rear, 54°, 7 miles an hour.	Observed time of flight, 55½ seconds; range, 7,350 yards; deviation to the right of line of fire, 545 yards.	Mortar mounted on spring return carriage No. 2. R. Poole & Son Co. Obturating friction primers. Fired to sea. Initial velocity, 1,020 foot seconds. Charge obtained by computation. Firing suspended on account of accident to other mortar carriage. Barometer, 30.42; thermometer, 29°; humidity, 47. Firing conducted by Lieut. F. P. Peck, Ordnance Department, assistant proof officer.

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Record of firing with 12-inch B. L. cast-iron mortar, No. 23, Build

[Object of firing, to obtain target in comparison with

	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation	Pressure per square inch of bore.	Recoil.	Counter recoil.
			Lbs. Oz.			*Pounds.*	*Inches.*	°	*Pounds.*	*Ins.*	*Ins.*
A. M ..	8	Du Pont's brown prismatic V. M., lot 7; density, 1.835.	76 8	812+7	Mortar shell, lot 485; 3½ calibers long; band, 1½ inches from base.	811	91.8	60	D, 27,345 H, 26,071	15⅛	14½

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ers Iron Foundry, at Sandy Hook Proving Ground, February 2, 1894.

target made simultaneously from 12-inch steel mortar.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind from right and rear, 52°, 7 miles an hour.	Direction given by bore sights. Observed time of flight, 53⅓ seconds. The right spring cylinder was broken off at its junction with the cheek, all the bolts connecting the two being broken or the metal torn away around them so as to expose the Belleville springs at this point. The two bolts holding the right hydraulic cylinder to the upper bracket were broken off. There is a wide crack perpendicular to the spring cylinder, extending entirely across the right upper bracket, just above the shoulder where the hydraulic cylinder bears downward during recoil. The lower end of right hydraulic cylinder is about 2 inches away from it, bearing on the spring cylinder, and its upper end about 1 inch from the upper bracket; and the spring cylinder has fallen down about 2 inches, its lower end resting on the concrete foundation. The fracture of the metal of right spring cylinder indicates poor iron. Right piston rod bent slightly. Slight crack through left upper bracket, perpendicular to spring cylinder, and the rear bolt holding left hydraulic cylinder to upper bracket broken off. The mortar was returned nearly to the firing position. Both cheeks are unserviceable for further firing. Range, 7,550 yards. Deviation to right of line of fire, 475 yards.	Mortar mounted on original Easton and Anderson carriage. Oil removed and cylinders filled with glycerine and water (1 to 1) 11 gallons. Obturating friction primers. Fired to sea. Initial velocity, 1,026 foot seconds by trial. In attempting to traverse the carriage for this firing it was found that the upper roller path rested on the flanges of the rollers nearly all the way around. This must have been produced by the last round of previous firing, on January 25, 1894, but was not discovered at the time. It was pushed in place latterly by hydraulic jacks, and on falling into position a piece of the iron bracket which forms the bearing for the vertical shaft of the traversing gear was broken off. It was of triangular shape, about 7 inches high by 4 inches wide at the base, and came from the extreme lower end of the bracket, next to the gear, so that it did not interfere with the working of the carriage. Barometer, 30.42; thermometer, 29°; humidity, 47. Firing conducted by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with 12-inch B. L. cast-iron mortar, No. 51, Builder

[Object of firing, to obtain target in comparison with tar

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Time of flight.	Pressure per square inch of bore.	Recoil.
A. M.			*Lbs. Oz.*			*Pounds.*	*Inches.*	° ′	″	*Pounds.*	*Ins.*
Apr. 3	27	Du Pont's hexagonal M. W.; density, 1.725; granulation, 72.	29 8	.....	Shell, lot 563; band, 1¼ inches from base, 1¼ inches wide.	1,014	91.875	60 00	Lost.	P, 12,750 U, 12,800	14
Apr. 3	28		29 8	.....		1,014	91.875	60 00	Lost.	P, 12,800 U, 13,000	14
Apr. 3	29		29 8	.....		1,014	91.875	60 00	33	P, 12,750 U, 12,050	14
Apr. 3	30		29 8	.....	Shell rebanded; 3.86 calibers long; from same lot.	1,014	91.875	60 00	31½ 32	P, 12,700 U, 12,450	14
Apr. 3	31		29 8	.....		1,014	91.875	60 00	30½	P, 12,625 U, 12,800	14
Apr. 7	32		29 8	.....		1,014	91.875	60 00	Lost.	.....	14

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Iron Foundry, at Sandy Hook Proving Ground, April 3 and 7, 1894.

get made simultaneously from 12-inch B. L. steel mortar.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ins.			
14½	Calm	Struck in water and lost. Sighting changed for next shot.	

TARGET.

		From center of impact.					
		Range.	Deviation (right).	Longitudinal.		Lateral.	
				+	−	Right.	Left.
		Yards.	*Yards.*	*Yds.*	*Yds.*	*Yards.*	*Yds.*
14	Wind from right and rear, 85°, 4 miles an hour.	2,485	174	.....	11	.....	9.6
14	Wind from left and rear, 20°, 4 miles an hour.	2,497	183	1	.....	.....	.6
14	Wind from left, 90°, 4 miles an hour.	2,507	184	11	.....	.4	.....
14	Wind from left, 90°, 6 miles an hour.	2,507	187	11	.....	3.4	.....
14	Calm	2,484	190	.....	12	6.4	.....
		.....	.....	23	23	10.2	10.2

12,480 + 5 = 2,496; 918 + 5 = 183.6; 46 + 5 = 9.2; 20.4 + 5 = 4.08.

	Yards.
Greatest range	2,507
Least range	2,484
Dispersion in range	23
Greatest deviation from plane of fire	190
Least deviation from plane of fire	174
Lateral dispersion	16
Mean range	2,496
Mean lateral deviation from plane of fire	183.6
Mean longitudinal deviation from center of impact	9.2
Mean lateral deviation from center of impact	4.08
Mean absolute deviation from center of impact	10.06

Mean angular deviation from plane of fire, 4° 13′ 10″.

Mortar mounted on spring return carriage No. 16. E. Poole & Son Co.
Obturating friction primers.
Fired down the beach.
Copper cylinders of 9,000 pounds initial compression and tables of 1890.
The charge is taken from previous firing and gives 554 foot seconds.
Each round on the third was followed by a round from the steel mortar as soon as the time of flight was observed, the interval being about one minute.
The piece was aimed by a brass pointer attached to lower roller path and a vertical line on a brass plate attached to upper roller path.

	Apr. 3.	Apr. 7.
Barometer	30.51	30.31
Thermometer, dry	39°	43°
Thermometer, wet	32°	35°
Humidity	43	41

Firing conducted by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with 12-inch B. L. cast-iron mortar, No. 51, Builders Iron

[Object of firing, to obtain target in comparison with ta

Date.	No. of fire.	Powder. Kind.	Weight.	No. of prisms.	Projectile. Kind.	Weight.	Travel of shot in bore.	Elevation.	Time of flight.	Pressure per square inch of bore.	Recoil.
A. M.			*Lbs.* *Oz.*			*Pounds.*	*Inches.*	° ′	″	*Pounds.*	*Ins.*
Apr. 7	33	Du Pont's brown prismatic V. M., lot 7; density, 1.835.	76 8	813—7	Shell, lot 485; 3¼ calibers long; band, 11 inches from base, 1¼ inches wide.	811	91.6	60 00	53½	P, 26,100 U, 25,470	14
Apr. 7	34		76 8	813—7		811	91.6	60 00	53	P, 26,400 U, 26,200	14
Apr. 7	35		76 8	813—7		811	91.6	60 00	53	P, 25,950 U, 25,900	14
Apr. 7	36		76 8	813—7		811	91.6	60 00	52⅞	P, 26,600 U, 25,700	14
Apr. 7	37		76 8	813—7		811	91.6	60 00	52⅝	P, 26,040 U, 25,770	14

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Foundry, at Sandy Hook Proving Ground, April 3 and 7, 1894—Continued.

get made simultaneously from 12-inch B. L. steel mortar.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.

TARGET.

		Range.	Deviation (right).	From center of impact. Longitudinal. +	Longitudinal. —	Lateral. Right.	Lateral. Left.	
Ins.		*Yards.*	*Yards.*	*Yds.*	*Yds.*	*Yards.*	*Yds.*	
14	Wind from left and front, 17°, 9 miles an hour.	7,449	445	15	.....	10.8	.....	Mortar mounted on spring return carriage No. 16. R. Poole & Son Co.
14	Wind from left and front, 17°, 9 miles an hour.	7,427	450	.....	7	15.8	.....	Obturating friction primers.
14	Wind from left and front, 7°, 9 miles an hour.	7,481	436	47	.....	1.8	.....	Fired to sea.
14	Wind from left and front, 7°, 10 miles an hour.	7,381	426	.....	53	.....	8.2	Copper cylinders of 24,000 pounds initial compression and tables of 1890.
14	Wind from left and front, 7°, 10 miles an hour.	7,432	414	.....	2	.....	20.2	The charge is taken from previous firing and gives 1,020 foot seconds.
		.....	.....	62	62	28.4	28.4	Each round followed a round from the steel mortar as soon as the records were obtained at the plane tables, the interval being about two minutes.

37,170 ÷ 5 = 7,434; 2,171 ÷ 5 = 434.2; 124 ÷ 5 = 24.8; 56.8 ÷ 5 = 11.36.

The piece was aimed by a brass pointer attached to lower roller path and a vertical line on a brass plate attached to upper roller path.

	Yards.
Greatest range	7,481
Least range	7,381
Dispersion in range	100
Greatest deviation from plane of fire	450
Least deviation from plane of fire	414
Lateral dispersion	36
Mean range	7,434
Mean lateral deviation from plane of fire	434.2
Mean longitudinal deviation from center of impact	24.8
Mean lateral deviation from center of impact	11.36
Mean absolute deviation from center of impact	27.28

Mean angular deviation from plane of fire, 3° 20′ 30″.

Barometer, 30.31; thermometer, dry, 43°; thermometer, wet, 35°; humidity, 41.

Observed at plane table at Navesink Highlands by Lieut. M. F. Harmon, First Artillery and on the fort wall by Mr. Richard Shorrock.

Firing conducted by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with 12-inch B. L. cast-iron mortar, No. 61, Builder

[Object of firing, to obtain velocities in connection with firing

Date.	No. of fire.	Powder.		Projectile.		Number stamped on base.	Travel of shot in bore.	Elevation.	Instrumental velocity 150 feet from muzzle.	Pressure per square inch of bore.
		Kind.	Weight.	Kind.	Weight.					
			Pounds.		*Pounds.*		*Inches.*	° ′	*Feet.*	*Pounds.*
A. M. Mar. 3	13	Du Pont's hexagonal M. W.; density, 1.725; granulation, 72.	28	Shell rebanded; 4¼ calibers long; band, 1½ inches from base.	1,014	37	91.7	1 18	552 553	D, 14,120 H, 13,940
P. M. Mar. 3	14		28		1.014	38	91.7	1 18	546 536 125+$\frac{9}{2}$	D, 13,600 H, 13,960
Mar. 12	15		28¾	Shell rebanded.	1,014	49	91.8	1 18	541 551	D, 13,840 H, 13,940
Mar. 12	16		29¼		1.014	50	91.8	1 18	543 552 125+$\frac{5}{2}$°	D, 14,360 H, 13,700

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Iron Foundry, at Sandy Hook Proving Ground March 3 and 12, 1894.

to obtain comparative targets with steel and cast-iron mortars.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.	*Ft. In.*			
3 4	3 11	Wind from rear 90°, 13 miles an hour.	Struck in butt, 5 planks below top of opening. Copper cylinders of 9,000 pounds initial compression and tables of 1892.	Mortar mounted on proof carriage (Krupp). Obturating friction primers. Fired into sand butt No. 2. Barometer, 30.33; thermometer, 46°; humidity, 45. Firing conducted by Lieut. M. F. Harmon, First Artillery.
3 4	3 4		Copper cylinders of 9,000 pounds initial compression and tables of 1892.	
4 0	4 0	Wind from front, 150, 8 miles an hour.	Copper cylinders of 9,000 pounds initial compression and tables of 1892.	Mortar mounted on proof carriage (Krupp). Obturating friction primers. Fired into sand butt No. 2. Barometer, 30.04; thermometer, 49°; humidity, 39. Firing conducted by Lieut. M. F. Harmon, First Artillery.
4 4	4 4		Copper cylinders of 9,000 pounds initial compression and tables of 1892.	

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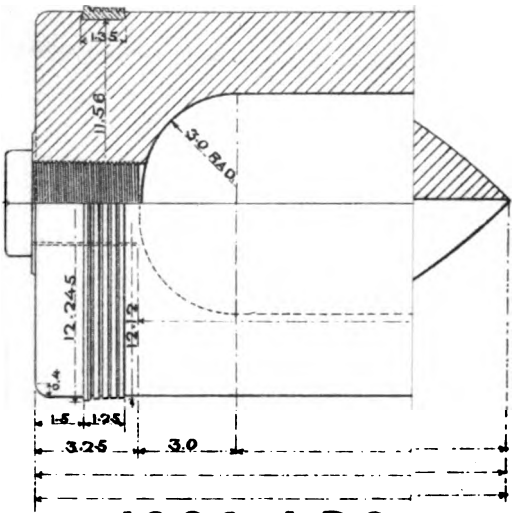
800 LBS.



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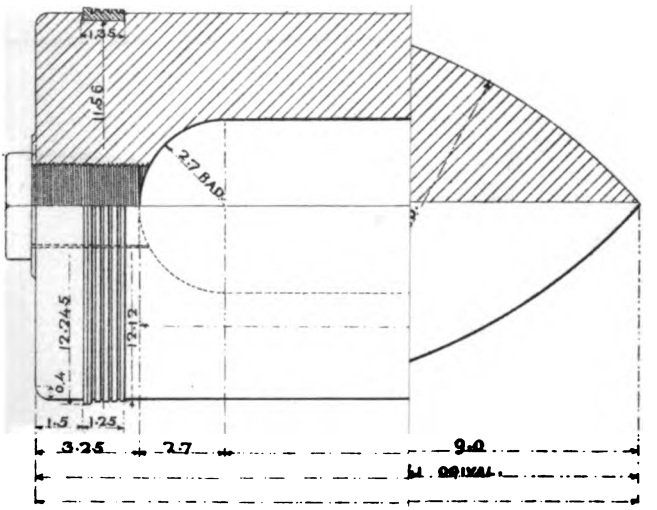

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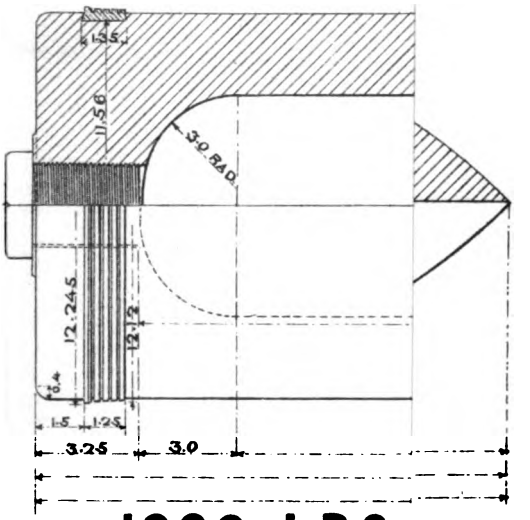

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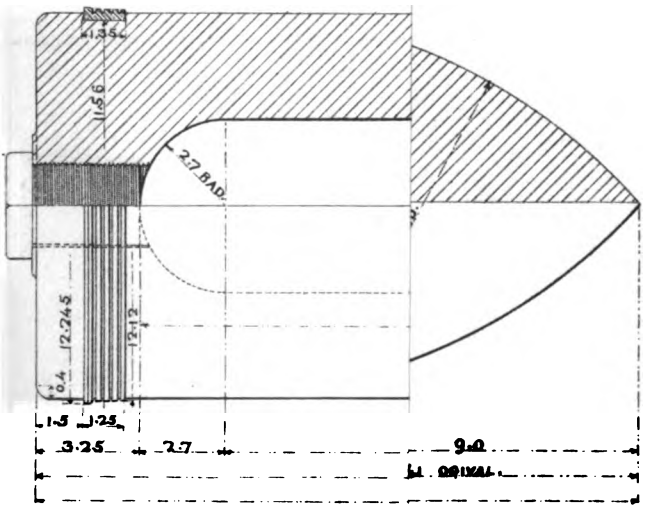

Appendix 21, 1894.

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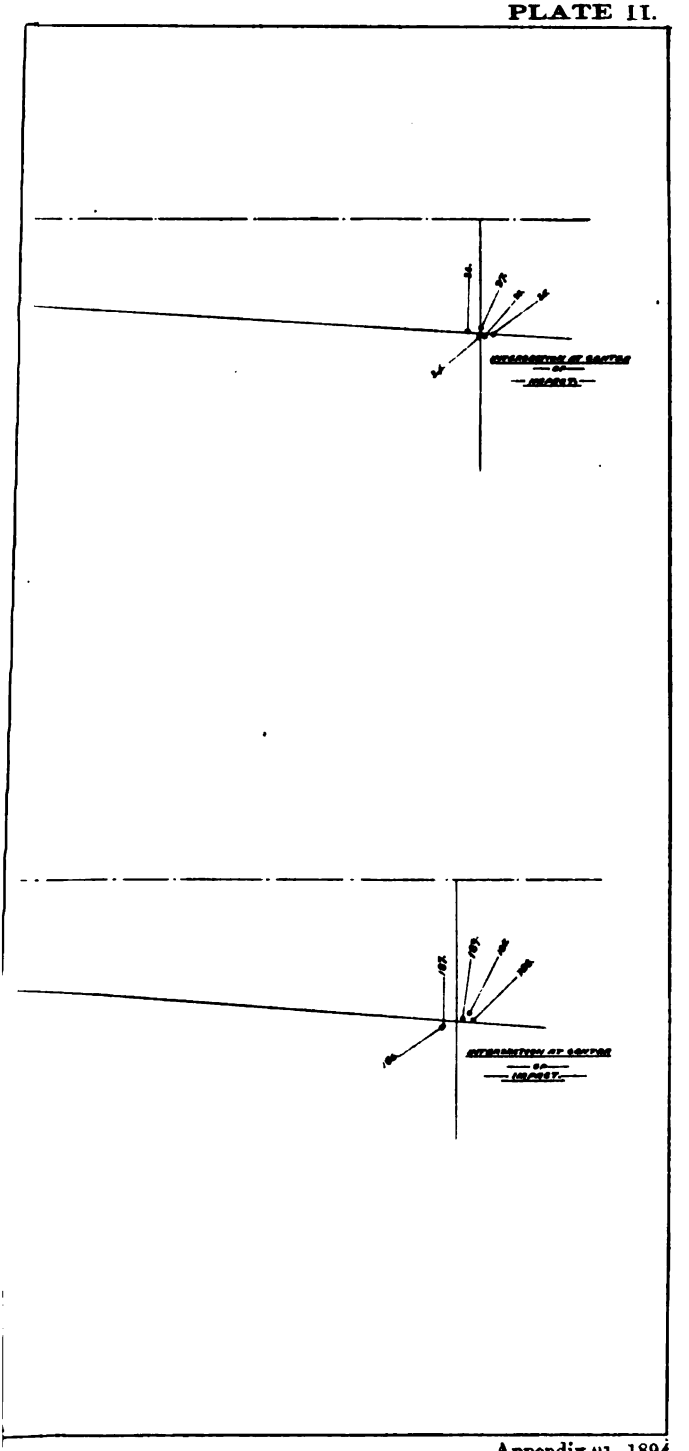

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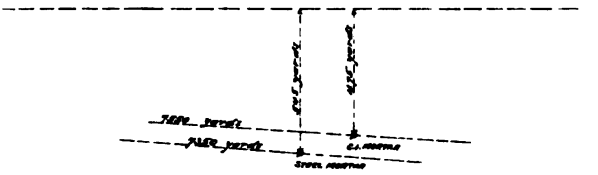

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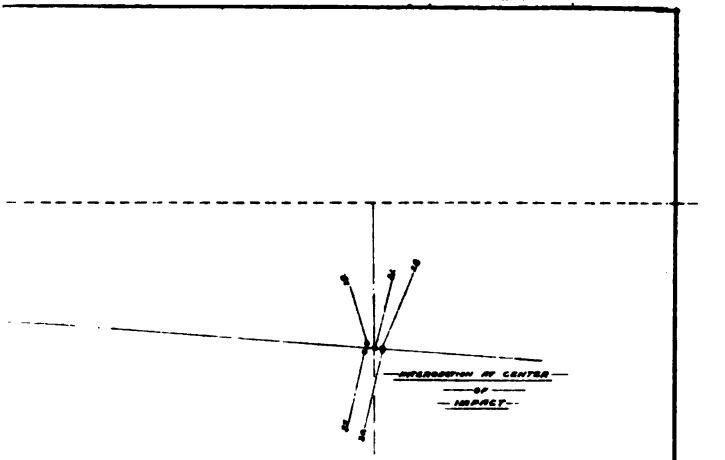

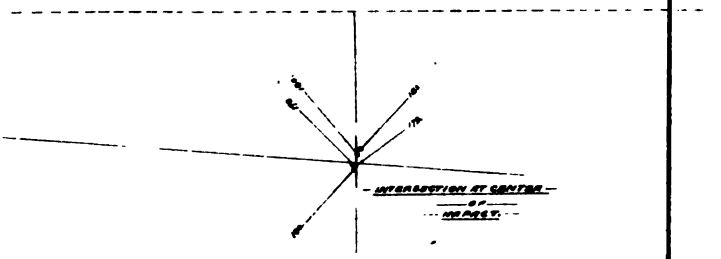

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PLATE V

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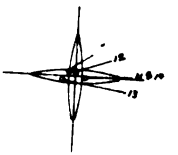

(Approx.) U.S. Protected Cruiser Philadelphia

Center of intersection = center of impact.

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APPENDIX 22.

RANGE TABLE FOR 3.2-INCH FIELD GUNS WITH SHELL AND SHRAPNEL.

(3 plates.)

SANDY HOOK PROVING GROUND,
October 12, 1893.

SIR: In accordance with your instructions, I have the honor to submit the following report on the determination of a range table for the 3.2-inch steel field gun:

Before beginning the firing for the range table proper, an attempt was made to ascertain the acceleration of the projectile from the muzzle to the point of maximum velocity, and the position of this point. The velocity was thus measured at 10 points 20 feet apart in front of the muzzle, but not with sufficient accuracy to be of use in applying to computations on the trajectory near the muzzle; and the reduction of the instrumental velocity to the muzzle has therefore been made by Ingalls's equations as if the projectile had moved through quiescent air. In order to determine small *c* for use with Ingalls's equations, velocities were taken with both shell and shrapnel at points nearly 1,000 yards apart, the data for this firing being here given in full.

Common shell.

[Band 0.625" from base; weight, 13.5 pounds.]

Velocity at 202 feet from muzzle.	Velocity at 3,000 feet from muzzle.	Loss in velocity.	Barometer.	Thermometer.		Wind, miles per hour.	Longitudinal component of wind, foot seconds.
				Dry.	Wet.		
1,598	1,213	385	30.39	68	54	25 from right and front 36°	Front 29.7.
1,608.2	1,213.4	394.8	30.39	68	54	23 from right and front 47°	Front 23.
1,596.4	1,206.1	390.3	30.40	66	56	13 from right and front 69°	Front 6.8.
1,626.4	1,233.2	393.2	30.40	66	56	....do	Do.
1,592.8	1,217.4	375.4	30.42	68	59	15 from right and rear 35°	Rear 18.
1,603.3	1,213.6	389.7	30.41	69	60	....do	Do.
1,609.3	1,232.2	377.1	30.41	71	61	14 from right and rear 35°	Rear 16.8.
1,592.1	1,223.1	369	30.39	78	69	13 from right and rear 35°	Rear 15.6.
1,607.8	1,228.9	378.9	30.39	77	67	12 from right and rear 35°	Rear 14.4.
1,597.2	1,219.9	377.3	30.38	76	64	18 from right and rear 35°	Rear 21.6.
1,598.9	1,216.2	382.7	30.38	74	59	19 from right and rear 77°	Rear 6.3.
1,595.2	1,210.4	384.8	30.38	73	57	....do	Do.

Shrapnel.

1,602.3	1,180.6	421.7	30.28	81	65	8 from right and rear 16°	Rear 11.3.
1,599.1	1,184.2	414.9	30.27	82	65	14 from right and front 55°	Front 11.8.
1,609	1,188	421	30.27	82	65	....do	Do.
1,613.8	1,200.8	413	30.27	82	65	14 from right and front 78°	Front 4.3.
1,607.4	1,182.9	424.5	30.27	80	63	....do	Do.
1,577.1	1,166.1	411	30.21	65	55	8 from right and rear 55°	Rear 6.6.
1,603.9	1,184.3	419.6	30.20	66	56	10 from right and front 38°	Front 11.6.
1,601.3	1,174.5	426.8	30.19	68	58	10 from left and front 39°	Do.
1,584.5	1,153.5	431	30.16	67	56	20 from right and front 9°	Front 29.
1,597.3	1,170.7	426 6	30.15	67	56	20 from right and front 15°	Front 28.3.

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From these the mean value of small c for common shell is 0.93 nearly, and for shrapnel 1.03; and with these values the following tables were computed, taking $V=1{,}685$ foot seconds.

Range table for common shell.

Range.	Angle of departure.	Angle of fall.	Time of flight.	Remaining velocity.
Yards.	° ′	° ′	″	*Ft. secs.*
500	0 32	0 36	0.96	1,450
600	0 39	0 45	1.17	1,408
700	0 47	0 54	1.39	1,366
800	0 55	1 05	1.61	1,326
900	1 03	1 16	1.84	1,287
1,000	1 12	1 28	2.07	1,250
1,100	1 21	1 41	2.32	1,215
1,200	1 30	1 55	2.57	1,182
1,300	1 40	2 09	2.82	1,151
1,400	1 50	2 25	3.09	1,121
1,500	2 01	2 41	3.36	1,094
1,600	2 12	2 59	3.64	1,070
1,700	2 23	3 17	3.92	1,048
1,800	2 35	3 36	4.21	1,029
1,900	2 47	3 56	4.50	1,011
2,000	3 00	4 17	4.80	994
2,100	3 13	4 38	5.10	979
2,200	3 27	5 00	5.41	964
2,300	3 41	5 23	5.72	949
2,400	3 55	5 47	6.04	935
2,500	4 09	6 11	6.37	922
2,600	4 24	6 37	6.70	909
2,700	4 40	7 03	7.03	896
2,800	4 56	7 30	7.37	883
2,900	5 12	7 58	7.71	871
3,000	5 29	8 27	8.06	859
3,100	5 46	8 56	8.41	847
3,200	6 04	9 26	8.77	836
3,300	6 22	9 57	9.13	825
3,400	6 40	10 29	9.49	814
3,500	6 59	11 01	9.86	803
3,600	7 18	11 34	10.23	793
3,700	7 38	12 08	10.61	783
3,800	7 58	12 43	10.99	773
3,900	8 18	13 18	11.37	764
4,000	8 39	13 54	11.76	755
4,100	9 00	14 31	12.15	746
4,200	9 22	15 09	12.55	737
4,300	9 44	15 47	12.95	729
4,400	10 06	16 26	13.35	721
4,500	10 29	17 05	13.75	713

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Range table for shrapnel.

Range.	Angle of departure.	Angle of fall.	Time of flight.	Remaining velocity.
Yards.	° ′	° ′	″	*Ft. secs.*
500	0 33	0 37	.97	1,426
600	0 40	0 46	1.18	1,380
700	0 48	0 56	1.40	1,335
800	0 56	1 06	1.63	1,292
900	1 04	1 19	1.87	1,251
1,000	1 13	1 32	2.11	1,212
1,100	1 23	1 45	2.36	1,176
1,200	1 33	2 01	2.62	1,142
1,300	1 44	2 17	2.89	1,110
1,400	1 55	2 34	3.16	1,082
1,500	2 06	2 52	3.44	1,056
1,600	2 17	3 11	3.73	1,034
1,700	2 29	3 30	4.02	1,014
1,800	2 42	3 50	4.32	995
1,900	2 55	4 12	4.62	978
2,000	3 09	4 34	4.93	962
2,100	3 23	4 57	5.25	946
2,200	3 37	5 21	5.57	930
2,300	3 52	5 45	5.90	915
2,400	4 07	6 11	6.23	901
2,500	4 23	6 38	6.56	887
2,600	4 39	7 05	6.90	873
2,700	4 55	7 34	7.25	860
2,800	5 12	8 04	7.60	847
2,900	5 30	8 35	7.96	835
3,000	5 48	9 07	8.32	823
3,100	6 07	9 39	8.69	811
3,200	6 26	10 12	9.06	800
3,300	6 45	10 46	9.44	789
3,400	7 05	11 21	9.82	779
3,500	7 25	11 56	10.20	769
3,600	7 46	12 32	10.59	759
3,700	8 07	13 09	10.98	750
3,800	8 28	13 48	11.38	741
3,900	8 50	14 28	11.78	733
4,000	9 12	15 08	12.19	725
4,100	9 34	15 40	12.60	718
4,200	9 56	16 31	13.02	711
4,300	10 19	17 14	13.44	704
4,400	10 42	17 58	13.86	698
4,500	11 05	18 43	14.29	692

The jump of the piece, using a velocity very nearly equal to the standard, was determined for each degree from 0° to 10° and the results are embodied on the diagram, Pl. I, where the ordinates of the curve represent very nearly the jump corresponding to different elevations, as abscissæ. In obtaining the data for this curve the carriage was on a horizontal plank platform with a concrete bed; the shots were fired through a vertical screen placed 100 feet from the muzzle and the level of each shot hole with respect to the muzzle in the firing position was determined; adding to the height of each shot hole the space through which a body would fall by gravity during the time of flight of the projectile gives the point where the tangent to the actual trajectory at its origin pierces the screen.

The difference between the angle of departure thus determined and the elevation given by the quadrant is the jump.

The time of flight to the screen was measured by a chronograph. Three shots were fired for jump from the fort wall, the muzzle nearly projecting over the edge of the wall, which is about 15 feet high.

The quadrant elevation was 54 feet and the jump was 11½ feet, or 9½ feet less than the jump for the same elevation when fired from a platform on a level with the ground, the nature of the platform being the same in the two cases.

With the carriage on the fort wall but 10 feet in the rear of the position from which the jump was measured, a number of shots were fired in groups of three at the various ranges from 1,000 yards up to 4,700 yards. The data for this firing are here given in full.

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Common shell.

[Band, 0.625″ from base; weight, 13.5 pounds. Velocity at 125 feet from muzzle = 1,660 foot seconds (= 1,681 foot seconds at muzzle—Ingalls).]

Number of shot.	Quadrant elevation.	Depression below muzzle of point struck.	Angle of sight.	Jump.	Angle of departure.	Actual range.	Barometer.	Thermometer. Dry.	Thermometer. Wet.	Wind, miles per hour.	Longitudinal component of wind, feet per second.	Reduced range, calm, standard air at 62° 30′, and two-thirds saturation: V = 1,685 foot seconds.
	° ′	′ ″	° ′ ″	′ ″	° ′	*Feet.*						*Yards.*
1	0 50	13 11	1 3 11	13 50	1 17	3,370	30.02	73	65	7 from right and rear 40°	Rear 7.8	1,115
2	0 50	14 10	1 4 10	13 50	1 18	3,313	30.02	73	65	do	do	1,096
3	0 50	14 42	1 4 42	13 50	1 19	3,239	30.02	73	65	do	do	1,072
4	1 39	9 17	1 48 17	15 10	2 3	4,512	30.00	78	66	1 from right and rear 20°	Neglect	1,498
5	1 39	Struck in water.										
6	1 39	9 6	1 48 6	15 10	2 3	4,539	30.00	78	66	do	do	1,507
7	2 0	7 11	2 7 11	15 35	2 23	5,155	30.00	78	66	1 from left and front 80°	do	1,710
8	2 0	7 32	2 7 32	15 35	2 23	5,092	30.00	78	66	do	do	1,691
9	2 0	7 33	2 7 33	15 35	2 23	5,134	30.00	78	66	Calm	0	1,705
10	3 47	Struck in water.										
11	3 34	7 15	3 41 15	17 25	3 59	7,255	30.00	78	66	1 from left and rear 50°	Neglect	2,403
12	3 34	7 17	3 41 17	17 25	3 59	7,374	30.00	78	66	1 from right and rear 80°	do	2,442
13	3 34	7 6	3 41 6	17 25	3 59	7,298	30.00	78	66	Calm	0	2,418
14	5 9	2 19	5 11 19	18 30	5 30	9,113	30.00	81	68	12 from right 90°	0	3,008
15	5 9	2 34	5 11 34	18 30	5 30	9,222	30.00	81	68	do	0	3,046
16	5 9	3 10	5 12 10	18 30	5 31	9,284	30.00	81	68	do	0	3,066
17	6 40	4 48	6 44 46	19 00	7 4	10,607	30.06	70	64	14 from direct front	Front 21	3,597
18	6 40	4 46	6 44 46	19 00	7 4	10,576	30.06	70	64	do	do	3,587
19	6 40	4 51	6 44 51	19 00	7 4	10,625	30.06	70	64	do	do	3,603
20	8 26	3 12	8 29 12	20 30	8 50	12,269	30.06	70	64	14 from right and front 20°	Front 20	4,163
21	8 26	3 19	8 29 19	20 30	8 50	12,416	30.06	70	64	14 from right and front 25°	Front 19	4,207
22	8 26	3 4	8 29 4	20 30	8 50	12,218	30.06	70	64	14 from right and front 20°	Front 20	4,145
23	10 42	2 35	10 44 35	30 00	11 15	13,981	30.06	70	64	14 from direct front	Front 21	4,753
24	10 42	3 39	10 45 39	30 00	11 16	14,252	30.06	70	64	14 from right and front 30°	Front 17	4,829
25	10 42	3 00	10 45 0	30 00	11 15	14,055	30.06	70	64	14 from right and front 10°	Front 20	4,773

Shrapnel.

1	2 5	6 10	2 11 10	15 45	2 27	5,189	30.00	81	68	7 from right and rear 80°	Rear 1.8	1,716
2	2 5	7 54	2 12 54	15 45	2 29	5,004	30.00	81	68	do	do	1,653
3	2 5	7 39	2 12 39	15 45	2 28	5,131	30.00	81	68	do	do	1,695
4	3 40	6 16	3 46 16	17 32	4 4	7,294	30.00	81	68	do	do	2,406
5	3 40	7 24	3 47 24	17 32	4 5	7,300	30.00	81	68	do	do	2,407
6	3 40	7 31	3 47 21	17 32	4 5	7,316	30.00	81	68	12 from right and rear 80°	Rear 2.7	2,411

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In correcting the ranges for longitudinal effect of wind in the above table, the method given by Lieut. Whistler in the Journal United States Artillery for July, 1892, was used; and in reducing the actual ranges to standard conditions and 1,685 foot seconds' velocity certain approximations were made to shorten the computations, but the resulting errors will probably not exceed in any case the variation caused by 1 foot of elevation.

It will be observed that the jump opposite any particular quadrant elevation is 7 feet less than given by the jump curve. The reason for this is as follows: At the quadrant elevation of 54 feet the jump from the fort wall was found to be 9½ feet less than when on the platform on the ground; but by using the reduced range of the second shell, which is the most probable of the first group of three, and c=.93, the angle of departure is found by computation to be 4 feet less than by applying the jump curve. Now, since the value of c was determined by firing at this range, its application to determine the angle of departure for this range is more reliable than for any other. Therefore a mean of these two differences, or 7 feet approximately, is taken to be the uniform excess of jump at the platform at which determined over the jump at the platform from which the firing for range was made.

An explanation of this difference is offered as follows: Firing from the level of the ground, the gases, spreading out with much higher velocity than the projectile has, are reflected upward as they reach the ground for some distance in front of the muzzle and produce an upward pressure on the projectile in its flight; firing over a wall, this element of the jump does not exist. If this is true, we would expect that, as the muzzle was brought back from the crest of the wall, the jump would gradually increase to its value when firing from the level of the ground. The firing for range was made with the muzzle about 12 feet from the crest, so that 7 feet would seem to be a fair value for the difference between the two cases. Surely this value is closer the truth than the variations in the jump due to service conditions on account of different soils, the sinking of trail and wheels in the ground, or the inclination of ground with the horizontal.

From the angles of departure thus found and the reduced ranges from actual firing, the following curve (Pl. II) for the angle of departure for common shell was made. The lower curve differs from it by the jump taken from the jump curve, and gives the angle of sight to be used when firing from a level platform on a level with the ground. In the corresponding diagram (Pl. III) for shrapnel, the angle of departure curve is made from the computed table and the angle of sight curve from it, as before.

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The following are the corrected range tables:

3.2-inch B. L. rifle.

[Shell, 13.5 pounds. Muzzle velocity, 1,685 foot seconds.]

Range.	Elevation.	Variations.		Time of flight.	Fall.		Terminal velocity.
		Range, 1 minute elevation.	Deflection, 1 division hor. scale.		Angle.	Inclination, 1 yard in—	
Yards.	° ′	*Yards.*	*Feet.*	*Secs.*	° ′	*Yards.*	*Ft. sec.*
500	0 12	14	4.4	0.96	0 36	95	1,450
600	0 19	13	5.2	1.17	0 45	76	1,408
700	0 26	12	6.1	1.39	0 54	64	1,366
800	0 34	12	7.0	1.61	1 5	53	1,326
900	0 42	12	7.8	1.84	1 16	45	1,287
1,000	0 51	11	8.7	2.07	1 28	39	1,250
1,100	1	11	9.6	2.32	1 41	34	1,215
1,200	1 9	11	10.4	2.57	1 55	30	1,182
1,300	1 18	10	11.3	2.82	2 9	27	1,151
1,400	1 28	10	12.2	3.09	2 25	24	1,121
1,500	1 38	10	13.0	3.36	2 41	21	1,094
1,600	1 49	10	13.9	3.64	2 59	19	1,070
1,700	2	9	14.8	3.92	3 17	17	1,048
1,800	2 11	9	15.7	4.21	3 36	16	1,029
1,900	2 23	9	16.5	4.50	3 56	15	1,011
2,000	2 35	8	17.4	4.80	4 17	13	994
2,100	2 48	8	18.3	5.10	4 38	12	979
2,200	3 2	8	19.1	5.41	5	11	964
2,300	3 16	7	20.0	5.72	5 23	11	949
2,400	3 30	7	20.9	6.04	5 47	10	935
2,500	3 44	7	21.7	6.36	6 11	9	923
2,600	3 58	7	22.6	6.69	6 37	9	912
2,700	4 12	7	23.5	7.02	7 3	8	901
2,800	4 27	7	24.4	7.35	7 30	8	891
2,900	4 42	7	25.2	7.68	7 58	7	881
3,000	4 58	6	26.1	8.01	8 27	7	871
3,100	5 14	6	27.0	8.35	8 56	6	861
3,200	5 30	6	27.8	8.69	9 26	6	851
3,300	5 46	6	28.7	9.03	9 57	6	841
3,400	6 3	6	29.6	9.37	10 29	5	832
3,500	6 21	6	30.5	9.71	11 1	5	823
3,600	6 39	6	31.3	10.06	11 34	5	814
3,700	6 57	6	32.2	10.41	12 8	5	806
3,800	7 15	5	33.1	10.77	12 43	4	798
3,900	7 33	5	33.9	11.13	13 18	4	790
4,000	7 52	5	34.8	11.50	13 54	4	782
4,100	8 11	5	35.7	11.87	14 31	4	774
4,200	8 30	5	36.5	12.25	15 9	4	766
4,300	8 50	5	37.4	12.63	15 47	4	758
4,400	9 10	5	38.3	13.02	16 26	3	750
4,500	9 31	5	39.2	13.42	17 5	3	743

REMARKS.

The angle of jump varies from about 20 minutes at 1° to 30 minutes at 10° elevation. Its value is not included in the column of "Elevation."

Each division of the horizontal scale of the 3.2-inch breech sights now in use equals 1-345th part of the distance between sights, thus giving a correction of about 0.9 of a foot for deflection for each 100 yards of the range. This variation is tabulated under the heading "Deflection for 1 division of the horizontal scale."

The rear sights now being issued for 3.2-inch field guns have range scales in yards for shrapnel and shell engraved upon the sight in addition to the degree scale.

The scale of yards for shrapnel, on the rear face of the sight, left side, is arranged with diagonal lines to be read in the same manner as the degree scale. Each diagonal embraces 250 yards of range, and there are 5 divisions on the upper edge of the slide, by which this space is subdivided, so that intervals of 50 yards in range are read directly from the scale.

The scale of yards for shell, on the front face of the sight, is marked for each 100 yards of range and is read from an index line on the slide.

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3.2-inch B. L. rifle.

[Shrapnel, 13.5 pounds. Muzzle velocity, 1,665 foot seconds.]

Range.	Elevation.		Variations.		Time of flight.	Fuse scale.			Change in height of burst, 1 minute elevation.	Fall.		Terminal velocity.
	Angle.	Differs from shell.	Range, 1 minute elevation.	Deflection, 1 division hor. scale.		Divisions.		Variation in range, 1 subdivision.		Angle.	Inclination, 1 yard in—	
Yards.	° ′	*Min.*	*Yards.*	*Feet.*	*Secs.*	*Units.*	*Sixths.*	*Yards.*	*Feet.*	° ′	*Yards.*	*Ft.sec.*
500	0 13	1	14	4.4	.97	0	4	80	.4	0 37	93	1,426
600	0 20	1	13	5.2	1.18	1	0	78	.....	0 46	75	1,380
700	0 27	1	12	6.1	1.40	1	1	75	.....	0 56	61	1,335
800	0 35	1	12	7.0	1.63	1	3	73	.....	1 6	52	1,292
900	0 43	1	12	7.8	1.87	1	4	71	.....	1 19	44	1,251
1,000	0 52	1	11	8.7	2.11	2	0	67	.9	1 32	37	1,212
1,100	1 2	2	11	9.6	2.36	2	1	67	.....	1 45	33	1,176
1,200	1 12	3	11	10.4	2.62	2	3	67	.....	2 1	28.5	1,142
1,300	1 22	3	10	11.3	2.89	2	5	62	.....	2 17	25	1,110
1,400	1 33	5	10	12.2	3.16	3	0	62	.....	2 34	22.5	1,082
1,500	1 44	6	9	13.0	3.44	3	2	58	1.3	2 52	20	1,056
1,600	1 55	6	9	13.9	3.73	3	4	58	.....	3 11	18	1,034
1,700	2 7	7	9	14.8	4.02	3	5	58	.....	3 30	16.5	1,014
1,800	2 19	8	8	15.7	4.32	4	1	55	.....	3 50	15	995
1,900	2 32	9	8	16.5	4.62	4	3	55	.....	4 12	13.5	978
2,000	2 45	10	7	17.4	4.93	4	5	52	1.7	4 34	12.5	962
2,100	2 59	11	7	18.3	5.25	5	1	52	.....	4 57	11.5	946
2,200	3 13	11	7	19.1	5.57	5	2	52	.....	5 21	10.5	920
2,300	3 28	12	7	20.0	5.90	5	4	50	.....	5 45	10	915
2,400	3 43	13	7	20.9	6.23	6	0	50	.....	6 11	9	901
2,500	3 58	14	6	21.7	6.56	6	2	49	2.2	6 38	8.5	887
2,600	4 14	16	6	22.6	6.90	6	4	49	.....	7 5	8	874
2,700	4 29	17	6	23.5	7.24	7	0	49	.....	7 34	7.5	862
2,800	4 44	17	6	24.4	7.58	7	2	49	.....	8 4	7	850
2,900	5 1	19	6	25.2	7.92	7	4	49	.....	8 35	6.5	839
3,000	5 18	20	6	26.1	8.26	8	1	48	2.6	9 7	6	829
3,100	5 35	21	6	27.0	8.61	8	3	48	.....	9 39	6	819
3,200	5 52	22	6	27.8	8.96	8	5	48	.....	10 12	5.5	810
3,300	6 9	23	5	28.7	9.32	9	1	47	.....	10 46	5.5	801
3,400	6 28	25	5	29.6	9.68	9	3	47	.....	11 21	5	792
3,500	6 47	26	5	30.5	10.04	9	5	45	3.0	11 56	4.5	783
3,600	7 6	27	5	31.3	10.41	10	1	45	.....	12 32	4.5	775
3,700	7 25	28	5	32.2	10.78	10	4	45	.....	13 9	4.5	767
3,800	7 45	30	5	33.1	11.16	11	0	44	.....	13 48	4	759
3,900	8 5	32	5	33.9	11.54	11	2	44	.....	14 28	4	751
4,000	8 25	33	5	34.8	11.92	11	5	44	3.5	15 8	3.5	744
4,100	8 44	33	5	35.7	12.30	12	1	44	.....	15 49	3.5	737
4,200	9 3	33	5	36.5	12.68	12	3	44	.....	16 31	3.5	730
4,300	9 24	34	5	37.4	13.06	12	5	43	.....	17 14	3	723
4,400	9 44	34	5	38.3	13.45	13	2	43	.....	17 58	3	717
4,500	10 5	34	5	39.2	13.84	13	4	43	3.9	18 43	3	711

REMARKS.

The tabular numbers of the column "Differs from shell" indicate the necessary increase of elevation in passing from shell to shrapnel firing, to attain the same range.

FUSE SCALE.

The fuse scale is based upon the time of burning in flight. Each unit (representing one second) is divided into six parts. The "units" are numbered and marked by through holes in the fuse cover.

The tabular numbers of the column "Divisions" indicate the point of the time train to be cut for each range. These numbers correspond to a time of flight which is generally less than the tabulated time of flight by an amount required to cause the shrapnel to burst at a point within a distance of 75 yards short of the target.

The bursting interval may be regulated by lengthening or shortening the cut of the fuse scale—using the tabular numbers of the column "Variation in range, 1 subdivision."

A common rule for height of burst is that the height above ground should not exceed 1 foot for each 100 yards of range (3 feet at 500, 10 feet at 1,000, 20 feet at 2,000 yards, etc.), or should, for every range be below a prolonged line inclined 10 minutes above the line joining gun and foot of target.

An observed height of burst may be regulated by the tabular numbers of the column "Change in height of burst for 1 minute elevation."

Example, illustrated by tabular numbers: Suppose the gun to be ranged to strike at the foot of the target at 2,000 yards. The bursting interval for the prescribed cut of 4 units and 5 sixths is then 0.1 of a second, or ($\frac{1}{10} \times 52 \div 4$) 31 yards short of the target. By the "inclination of fall" (1 yard in 12.5) the height of burst would be ($32 \times 3 \div 12.5$) about 7 feet. If it were desired to increase this height to 15 feet, for example, the 8 feet additional would be obtained by giving 4 minutes (of arc) more elevation to the gun, since, at this range, 1 minute corresponds to a change of 1.7 feet in the height of burst.

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STANDARD AIR.

In the ratio $\frac{\delta_1}{\delta}$ of Ingalls's equations, δ_1 is taken to be the weight of a cubic foot of dry air at 62° F. and 30 inches barometer. In a table prepared by Capt. C. E. Kilbourne, of the Signal Corps, based on the most recent data of the Smithsonian Institution, this is given as 529.3 grains. The denominator (δ) is the weight of a cubic foot of air two-thirds saturated at same temperature and barometer. Two-thirds saturation corresponds very nearly to a difference of 6.5° between the wet and dry bulb thermometers, so that the value of δ is 527.5 grains. These give for the coefficient C ($=\frac{\delta_1 w}{\delta c d^2}$) the following values: log. C (shell) = 0.15303; log. C (shrapnel) = 0.10867.

From data furnished by Capt. Kilbourne giving the mean relative humidity at several stations in the interior, it is found that two-thirds saturation is about the average condition for the interior as well as the seacoast, so that we may use the same standard condition for field practice as for seacoast artillery.

A copy of the table above mentioned, from which may be found the value of δ for any atmospheric conditions, is attached.

Nearly all the firings involved in the above and part of the computations were made by First Lieut. E. St. J. Greble, First Artillery, and myself together.

Very respectfully, your obedient servant,

FREMONT P. PECK,
Lieutenant, Ordnance Department.

The COMMANDING OFFICER SANDY HOOK PROVING GROUND.

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TABLE No. II.—*Weight of a cubic foot of air under a pressure of 30 inches, corresponding to different temperatures of the air (t) and different stages of humidity, as shown by the depression of the wet-bulb thermometer (t—t').*

To reduce to true values under the barometric pressure at time of observation, multiply by $\frac{\text{height of barometer.}}{30}$

[Weight in grains.]

Temperature of the air, °F.	Depression of wet-bulb thermometer (t—t').																											
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
26	569.0	569.1	569.3	569.4	569.5	569.7	569.8	569.9																				
28	566.5	566.7	566.8	566.9	567.0	567.2	567.3	567.4	567.6																			
30	564.1	564.2	564.4	564.5	564.6	564.7	564.9	565.0	565.1	565.2																		
32	561.6	561.8	561.9	562.0	562.2	562.3	562.4	562.6	562.7	562.8	562.9																	
34	559.2	559.3	559.5	559.6	559.7	559.9	560.0	560.2	560.3	560.4	560.5	560.6																
36	556.8	556.9	557.1	557.2	557.4	557.5	557.6	557.8	557.9	558.0	558.1	558.3																
38	554.4	554.5	554.7	554.8	555.0	555.1	555.2	555.4	555.5	555.6	555.8	555.9	556.0															
40	552.0	552.1	552.3	552.4	552.6	552.7	552.9	553.0	553.1	553.2	553.4	553.5	553.6															
42	549.6	549.8	549.9	550.1	550.2	550.4	550.5	550.6	550.8	550.9	551.0	551.2	551.3															
44	547.3	547.4	547.6	547.7	547.9	548.0	548.1	548.3	548.4	548.5	548.7	548.8	549.0	549.1														
46	544.9	545.0	545.2	545.3	545.5	545.6	545.8	545.9	546.1	546.2	546.4	546.5	546.6	546.8	546.9													
48	542.6	542.7	542.9	543.0	543.2	543.3	543.5	543.6	543.8	543.9	544.0	544.2	544.3	544.4	544.6													
50	540.2	540.4	540.5	540.7	540.9	541.0	541.2	541.3	541.5	541.6	541.7	541.9	542.0	542.2	542.3	542.4												
52	537.9	538.0	538.2	538.4	538.5	538.7	538.8	539.0	539.1	539.3	539.4	539.6	539.7	539.9	540.0	540.1	540.3											
54	535.6	535.7	535.9	536.0	536.2	536.4	536.6	536.7	536.8	537.0	537.2	537.3	537.5	537.6	537.7	537.9	538.0	538.1										
56	533.2	533.4	533.6	533.8	533.9	534.1	534.3	534.4	534.6	534.7	534.9	535.0	535.2	535.3	535.5	535.6	535.7	535.9										
58	530.9	531.1	531.3	531.5	531.6	531.8	532.0	532.1	532.3	532.5	532.6	532.8	532.9	533.0	533.2	533.3	533.5	533.6	533.8									
60	528.6	528.8	529.0	529.2	529.3	529.5	529.7	529.9	530.0	530.2	530.3	530.5	530.7	530.8	531.0	531.1	531.3	531.4	531.5									
62	526.3	526.5	526.7	526.9	527.1	527.2	527.4	527.6	527.8	528.0	528.1	528.3	528.4	528.6	528.7	528.9	529.0	529.2	529.3									
64	524.0	524.2	524.4	524.6	524.8	525.0	525.2	525.4	525.5	525.7	525.9	526.0	526.2	526.4	526.5	526.7	526.8	527.0	527.1									
66	521.8	522.0	522.2	522.4	522.6	522.8	522.9	523.1	523.3	523.5	523.6	523.8	524.0	524.1	524.3	524.5	524.6	524.8	524.9	525.1								
68	519.5	519.7	519.9	520.1	520.3	520.5	520.7	520.9	521.0	521.2	521.4	521.6	521.8	521.9	522.1	522.3	522.4	522.6	522.7	522.9								
70	517.2	517.4	517.6	517.8	518.0	518.2	518.4	518.6	518.8	519.0	519.2	519.4	519.6	519.7	519.9	520.1	520.2	520.4	520.5	520.7	520.8							
72	514.9	515.1	515.3	515.5	515.8	516.0	516.2	516.4	516.6	516.8	516.9	517.2	517.3	517.5	517.7	517.9	518.0	518.2	518.3	518.5	518.7	518.9						
74	512.6	512.8	513.1	513.3	513.5	513.7	513.9	514.1	514.3	514.5	514.7	515.0	515.2	515.3	515.5	515.7	515.8	516.0	516.2	516.4	516.5	516.7						
76	510.3	510.6	510.8	511.0	511.3	511.5	511.7	511.9	512.1	512.3	512.5	512.7	512.9	513.1	513.3	513.5	513.7	513.9	514.0	514.2	514.3	514.5	514.7					
78	508.0	508.3	508.6	508.8	509.0	509.2	509.5	509.7	509.9	510.2	510.3	510.5	510.7	510.9	511.1	511.3	511.5	511.7	511.9	512.1	512.2	512.4	512.6	512.8				
80	505.7	506.0	506.2	506.5	506.8	507.0	507.3	507.5	507.7	507.9	508.1	508.3	508.5	508.7	508.9	509.1	509.3	509.5	509.7	509.9	510.1	510.2	510.4	510.6				
82	503.4	503.7	504.0	504.2	504.5	504.7	505.0	505.2	505.4	505.7	505.9	506.1	506.3	506.6	506.8	507.0	507.2	507.4	507.6	507.7	507.9	508.1	508.3	508.5	508.6			
84	501.2	501.4	501.7	502.0	502.2	502.5	502.7	503.0	503.2	503.5	503.7	503.9	504.2	504.4	504.6	504.8	505.0	505.2	505.4	505.6	505.8	506.0	506.2	506.4	506.5	506.7		
86	498.9	499.2	499.4	499.7	500.0	500.2	500.5	500.8	501.0	501.3	501.5	501.7	502.0	502.2	502.4	502.6	502.8	503.0	503.2	503.4	503.6	503.8	504.0	504.2	504.4	504.6	504.8	
88	496.6	496.9	497.2	497.5	497.7	498.0	498.3	498.6	498.8	499.1	499.3	499.5	499.8	500.0	500.2	500.5	500.7	500.9	501.1	501.3	501.5	501.7	501.9	502.1	502.3	502.5	502.7	
90	494.3	494.6	494.9	495.2	495.5	495.8	496.0	496.3	496.6	496.8	497.1	497.3	497.6	497.8	498.1	498.3	498.5	498.8	499.0	499.2	499.4	499.6	499.8	500.0	500.2	500.4	500.5	500.7

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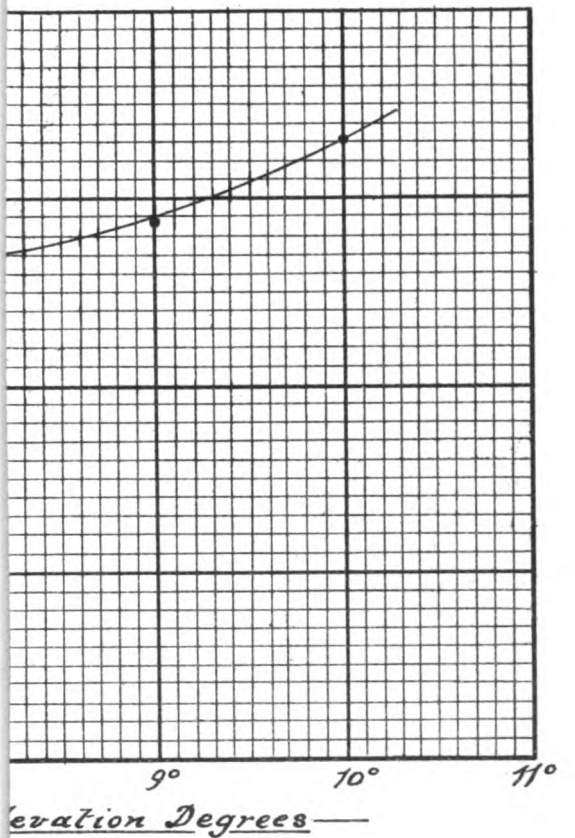

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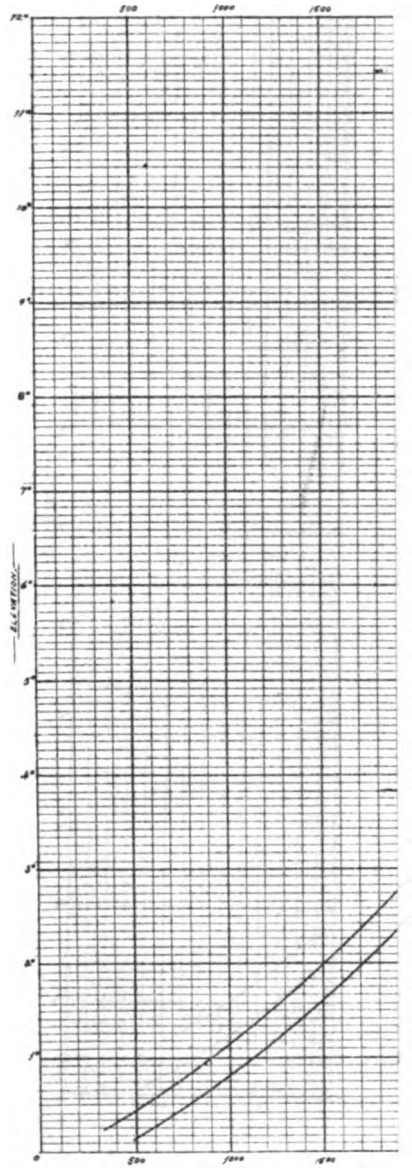

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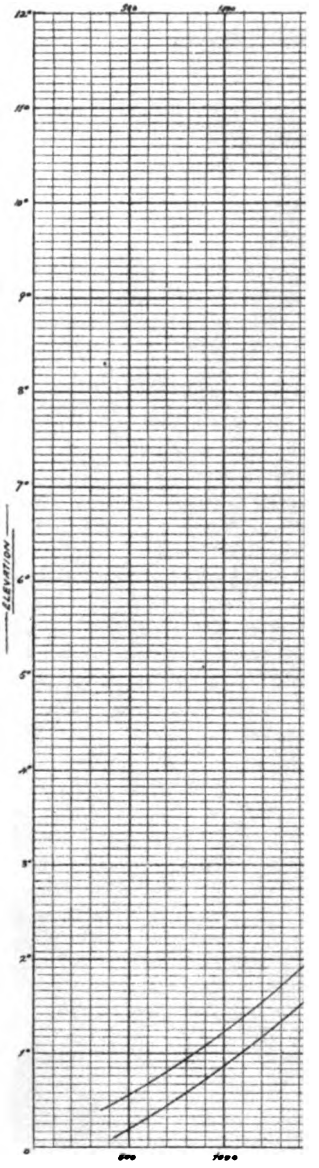

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APPENDIX 22*a*.

ACCURACY TRIALS OF A WORN 8-INCH B. L. RIFLE WITH ENLARGED ROTATING BANDS.

(2 plates.)

SANDY HOOK PROVING GROUND,
New York, N. Y., November 21, 1894.

SIR: I have the honor to forward herewith record of firings made with the 8-inch B. L. rifle No. 1, Watervliet Arsenal, in accordance with authority contained in O. O. file 3595 for the purpose of ascertaining whether in guns whose bores have become worn and scored by long use an increase in accuracy may be secured by providing their projectiles with rotating bands of greater thickness than in service projectiles.

In firings with the rifle above mentioned, as well as with the 10-inch B. L. rifle type, a considerable falling off in accuracy was noted, as erosion developed in the bores and chambers, and the rifling, especially in the vicinity of the forcing cone, became worn. Under these conditions the projectiles, in loading, were forced about an inch farther into the bore than the normal loading position, thereby reducing the density of loading and travel of shot for the same charge. Moreover, an examination of recovered projectiles clearly indicated that the rifling had not been properly taken, the rotating bands in many instances showing very faint marks of rifling, and in others the bands were sheared perfectly smooth, due, no doubt, to the great velocity with which the shot had entered that portion of the bore where the rifling was not worn, and was still of its normal depth. It was thought that these defects might be overcome by giving the rotating band sufficient increased thickness to cause the shot to stop at its proper loading position. In this way, as the original density of loading and travel of shot would be retained and the projectile be enabled to take the rifling while moving at a slow velocity, the accuracy of the gun should be restored.

Careful measurements indicated that increasing the thickness (diameter) of the band 0.0825 inch would be sufficient for the purpose.

Two targets of 10 shots each were made with projectiles having the service band and enlarged band respectively. In order that the weather conditions might be as nearly identical as possible, the shots were fired alternately. The platted targets, which accompany the record, indicate unusually good practice with both forms of band. That with the enlarged bands is, however, decidedly the better of the two; it is the best target ever made at this place with an 8-inch rifle, and demonstrates that after an 8-inch gun has been fired over 330 rounds it is possible to make it as accurate as when new by the simple method of increasing the diameter of the rotating bands of its projectiles.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. Army, Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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Record of firing with 8-inch B. L. rifle, steel, No. 1 type, Watervliet Arsenal,

[Object of firing, to test relative accuracy of projectiles with service bands and

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Deflection points (left).
P. M.			*Lbs. Oz.*			*Pounds.*	*Inches.*	° ′	
Nov. 10	329	Du Pont's brown prismatic powder, U. R., lot 5; density, 1.845.	62 13½ 63 13½ 0 5 127 0	618 668 Igniter.	Solid shot, lot 615, with service band.	301	202.625	Quadrant....1 48	
Nov. 10	330		63 13½ 62 13½ 0 5 127 0	689 677 Igniter.		300	202.90	Quadrant....1 30 Scott sight...0 46	
Nov. 10	331		63 13½ 62 13½ 0 5 127 0	697 681 Igniter.		301	202.75	Quadrant....1 22 Scott sight...0 40	
Nov. 10	332		62 13½ 63 13½ 0 5 127 0	678 681 Igniter.		301	202.625	Quadrant....1 22 Scott sight...0 40	7
Nov. 13	333		62 13½ 63 13½ 0 5 127 0	676 686 Igniter.		300	202.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	334		63 13½ 62 13½ 0 5 127 0	673 682 Igniter.		300	202.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	337		62 13½ 63 13½ 0 5 127 0	680 689 Igniter.		300	202.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	338		63 13½ 62 13½ 0 5 127 0	688 676 Igniter.		300	202.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	341		63 13½ 62 13½ 0 5 127 0	691 675 Igniter.		300	202.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	342		62 13½ 63 13½ 0 5 127 0	680 692 Igniter.		300	202.575	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	345		63 13½ 62 13½ 0 5 127 0	686 679 Igniter.		300	202.575	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	346		62 13½ 63 13½ 0 5 127 0	680 691 Igniter.		300	202.575	Quadrant....1 28 Scott sight...0 46	7

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at Sandy Hook Proving Ground, from November 10 to November 13, 1894.

with bands enlarged to correspond to the enlargement of the bore from erosion.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.	*Ft. In.*	*Ft. In.*			
J, 35,418 O, 35,491	4 4	4 4	Wind from right and rear, 45°, 10 miles an hour; barometer, 29.94; thermometer, 44°; humidity, 70.	Sighting shot. Missed target. Flight very unsteady.	Gun mounted on 8-inch proof carriage. Obturating friction primers. One-half pint of oil added to cylinders. 32,000 coppers of 1890. Scott sight No. 626 used. Fired at 1-mile target. The target could not be seen from the gun, owing to butt No. 2 being in the line of fire, and the gun was laid by the Scott sight, using a mark on the butt as a sighting point, 550 feet from the gun. The center of the target was in the plane of fire. The target was made, alternating every two shots with projectiles with enlarged bands. When the top carriage remained out of battery after firing it was sufficient to start it with a pinch bar to make it run in battery.
Q, 34,750 U, 35,289	4 4	2 0		Sighting shot. Apparently steady in flight. Struck 100 yards in rear and 20 feet right.	
B, 35,688 T, 35,650	4 4	2 0		Sighting shot. Steady in flight. Struck 50 yards in rear and 8 feet right.	
E, 34,893 V, 35,100	4 4	2 0		Sighting shot. Apparently steady in flight. Struck target 10 feet below and 4 feet right of center.	
B, 34,523 T, 34,600	4 4	4 4	Wind from right and front, 45°. 10 miles per hour.		
J, 35,200 O, 35,100	4 4	4 4		.....	
Q, 34,827	4 4	4 4	Wind from right and front, 45°. 8 miles per hour.	.....	
U, 35,356	4 4	4 4		.....	
J, 35,918	4 5	4 5		.....	
O, 34,965	4 5	0 2	Wind from right and front, 45°; barometer, 30.32; thermometer, 44°; humidity, 70. 6 miles per hour.	.....	
Q, 34,700	4 5	4 5		.....	
V, 35,918	4 5	0 2	4 miles per hour.	.....	

TARGET.

No. of round.	From center of target. Vertical. Above.	Vertical. Below.	Horizontal. Right.	Horizontal. Left.	From center of impact. Vertical. Above.	Vertical. Below.	Horizontal. Right.	Horizontal. Left.
333	....	2	5.5	....	1.4	....	1.5	....
334	....	1	2	....	2.4	....	....	2
337	....	1	2	....	2.4	....	....	2
338	2	....	3	....	5.4	....	....	1
341	....	5	4.5	....	....	1.6	0.5	....
342	....	7	2	....	....	3.6	....	2
345	....	3.5	4.5	....	....	0.1	0.5	....
346	....	7	7	....	....	3.6	3	....
349	....	4	5.5	....	....	0.6	1.5	....
350	....	5.5	4	....	....	2.1	0	

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Record of firing with 8-inch B. L. rifle, steel, No. 1 type, Watervliet Arsenal, [illegible]

[Object of firing, to test relative accuracy of projectiles with service bands and

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectiles. Kind.	Projectiles. Weight.	Travel of shot in bore.	Elevation.	Deflection points (left)
P. M.			*Lbs.* *Oz.*			*Pounds.*	*Inches.*	° ′	
Nov. 13	349	Du Pont's brown prismatic powder, U. R., lot 5; density, 1.845.	63 13½ 62 13½ 0 5 127 0	689 680 Igniter.	Solid shot, lot 615, with service band.	300	202.575	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	350		63 13½ 62 13½ 0 5 127 0	687 674 Igniter.		300	202.575	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	335		63 13½ 62 13½ 0 5 127 0	688 676 Igniter.	Solid shot, lot 625, with enlarged band.	300	204.00	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	336		63 13½ 62 13½ 0 5 127 0	687 677 Igniter.		301	203.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	339		63 13½ 62 13½ 0 5 127 0	691 675 Igniter.		300	204.00	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	340		63 13½ 62 13½ 0 5 127 0	692 675 Igniter.		300	203.75	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	343		63 13½ 62 13½ 0 5 127 0	687 677 Igniter.		300	203.50	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	344		63 13½ 62 13½ 0 5 127 0	691 681 Igniter.		300	203.50	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	347		63 13½ 62 13½ 0 5 127 0	687 681 Igniter.		300	203.625	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	348		63 13½ 62 13½ 0 5 127 0	687 674 Igniter.		301	203.625	Quadrant....1 28 Scott sight...0 46	7

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Sandy Hook Proving Ground, from November 10 to November 13, 1894—Continued.

with bands enlarged to correspond to the enlargement of the bore from erosion.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.	*Ft. In.*	*Ft. In.*			
J, 36,400	4 5	0 2	Wind from right and rear, 45°; barometer, 30.32; thermometer, 44°; humidity, 70; 3 miles per hour.		Center of impact— Feet. Below ..... 3.4 Right ..... 4 Mean vertical deviation from center of impact ..... 2.32 Mean horizontal deviation from center of impact ..... 1.4 Mean deviation from center of impact ..... 2.71 Mean deviation to right of plane of fire ..... 4 Firing conducted by Lieut. F. P. Peck, Ordnance Department, U. S. Army, Assistant Proof Officer.
O, 35,930	4 5	0 2			
E, 34,880	4 4	4 4			
V, 34,431	4 4	0 2	Wind from right and front, 45°; barometer, 30.32; thermometer, 44°; humidity, 70. 10 miles per hour.		
B, 35,717	4 5	4 5			
T 35,100	4 5	4 5	8 miles per hour.		Gun mounted on 8-inch proof carriage. Obturating friction primers. One-half pint of oil added to cylinders. 52,000 coppers of 1890. Scott sight No. 626 used. Fired at 1-mile target. The target could not be seen from the gun, owing to butt No. 2 being in the line of fire, and the gun was laid by the Scott sight, using a mark on the butt as a sighting point, 550 feet from the gun. The center of the target was in the plane of fire. The target was made, alternating every two shots with projectiles with service bands. When the top carriage remained out of battery after firing it was sufficient to start it with a pinch bar to make it run in battey.
E, 36,556	4 5	4 5	6 miles per hour.		
V, 35,953	4 5	0 2	Wind from right and rear, 45°. 4 miles per hour.		
B, 35,311	4 5	0 2			
T, 35,700	4 5	0 2	3 miles per hour.		

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Record of firing with 8-inch B. L. rifle, steel, No. 1 type, Watervliet Arsenal,

[Object of firing, to test relative accuracy of projectiles with service bands and

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Deflection points (left).
		Kind.	Weight.	No. of prisms.	Kind.	Weight.			
P. M.			*Lbs. Oz.*			*Pounds.*	*Inches.*	° ′	
Nov. 13	351	Du Point's brown prismatic powder, U. R., lot 5; density, 1.845.	62 13½ 63 13½ 0 5 127 0	675 686 Igniter.	Solid shot, lot 625, with enlarged band.	300	203.50	Quadrant....1 28 Scott sight...0 46	7
Nov. 13	352		63 13½ 62 13½ 0 5 127 0	683 675 Igniter.		300	203.575	Quadrant....1 28 Scott sight...0 46	7

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at Sandy Hook Proving Ground, from November 10 to November 13, 1894—Continued.

with bands enlarged to correspond to the enlargement of the bore from erosion.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.
Pounds.	*Ft. In.*	*Ft. In.*		
J, 36,100	4 5	0 2	Wind from right and rear, 45°. 3 miles per hour.	
O, 35,824	4 5	0 2	Wind from right and rear, 45°. 4 miles per hour.	

General remarks.

TARGET.

No. of round.	From center of target. Vertical. Above.	Below.	Horizontal. Right.	Left.	From center of impact. Vertical. Above.	Below.	Horizontal. Right.	Left.
335	2	....	3	....	1.8	....	....	0.4
336	....	0	3	....	....	0.2	....	0.4
339	0.5	....	4	....	1.8	....	0.6	....
340	0.5	....	3	....	0.3	....	....	0.4
343	1	....	3.5	....	0.8	....	0.1	....
344	....	0.5	4	....	....	0.7	0.6	....
347	....	3.5	3.5	....	....	3.7	0.1	....
348	....	1	2	....	....	1.2	....	1.4
351	2.5	....	4	....	2.3	....	0.6	....
352	....	1	4	....	....	1.2	0.6	....

	Feet.
Center of impact—.	
Above	0.2
Right	3.4
Mean vertical deviation from center of impact	1.4
Mean horizontal deviation from center of impact	.52
Mean deviation from center of impact	1.49
Mean deviation to right of plane of fire	3.4

Firing conducted by Lieut. F. P. Peck, Ordnance Department, U. S. Army, assistant proof officer.

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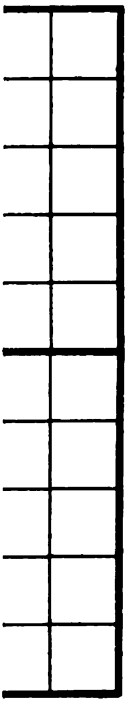

2'32

1'4

2'71

4'right

Appendix 22, A, 1894.

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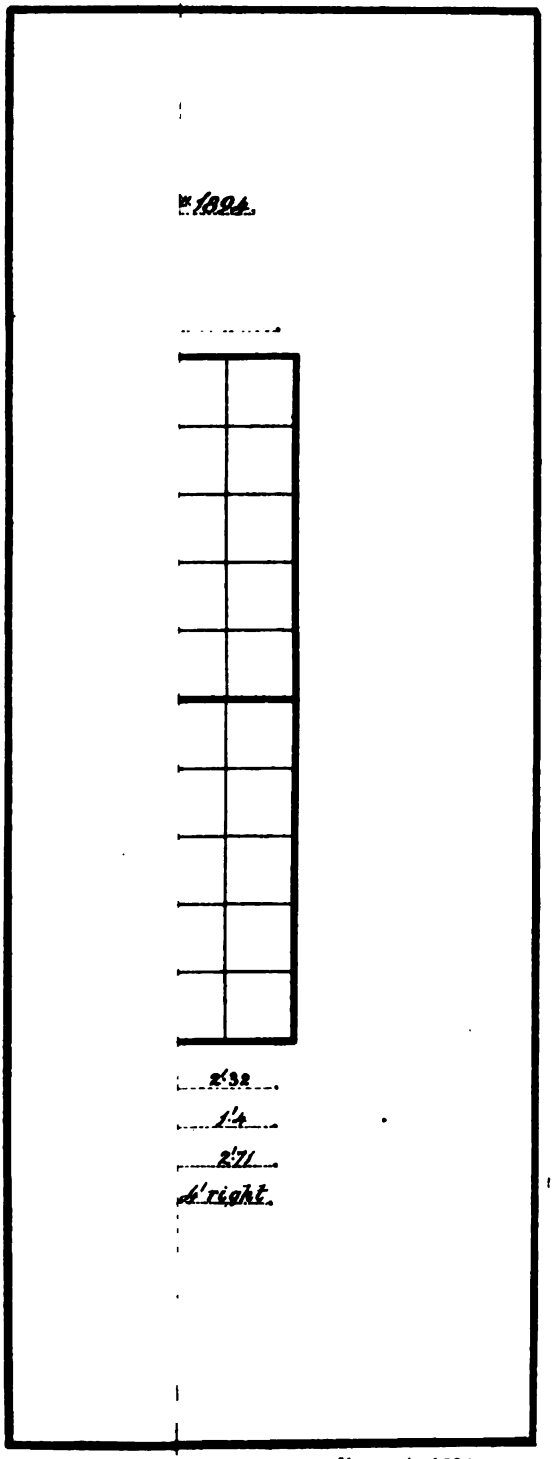

Appendix 22, A, 1894.

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APPENDIX 23.

REPORT OF THE INSPECTOR OF POWDER.

OFFICE OF THE INSPECTOR OF POWDER, U. S. ARMY,
Wilmington, Del., August 31, 1894.

SIR: I have the honor to submit, in compliance with your instructions, the report of this office for the year ending June 30, 1894.

This office was established early in the present calendar year, with a sphere of action coextensive with the subject of the supply of powder to the Army. The inspector is directed to extend his attention to the entire field, but particularly to seek to further the development of brown powder for the sea-coast guns and of smokeless powder for all classes. He also acts as inspector at the Du Pont Powder Works. Since, as is well known, these works supply nearly all the powder for the military service, these two functions are closely associated in practice. Thus far the work of the office in the more general function has been largely preparatory.

PROVING GROUND.

To facilitate the prosecution of its work, the Department has furnished to this office a 3.2-inch field gun and an 8-inch B. L. rifle, M. 1888 *m*, mounted on carriages, and an outfit of projectiles and of instruments for determining pressures and velocities. The Du Pont Company has furnished grounds for proof-ranges, with platforms, butts, targets, batteries, houses, etc., for the installation of the guns and outfit, and assumes the current expenses for labor, expendable material, etc. This arrangement is of benefit to the Government in that it contributes materially to progress in the solution of the questions in hand and relieves the proving ground at Sandy Hook of a certain amount of work not particularly germane to its functions; and to the Du Ponts by making possible tests for information during manufacture which may enable them to make necessary corrections as the manufacture proceeds, with a consequent saving of both powder and time. To the attainment of these benefits the parties contribute mutually as described.

The field gun was installed early in June, and up to the close of the fiscal year had been fired 19 times in manufacturer's tests of black and smokeless powders.

The installation of the 8-inch gun was not completed at the end of the period covered by this report. It has since been completed, however, with the exception of the chronographs, which have not yet been received. However, temporary use can be made of an instrument belonging to the company, and work with the gun will go on.

The field gun is located at the works. The 8-inch gun is located near Springfield Station, Pa., on the line of the Wilmington and Northern Railroad, about 45 miles from the works. This is the most conveniently accessible location, free from the almost prohibitive disadvantage of neighboring residences, that could be found. The distance, though

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a source of inconvenience, does not prevent or seriously hinder tests of the requisite frequency, and so will not detract greatly from the benefits derivable from the plant.

WAVE ACTION.

When, early in the year, the inspector began to consider the problem of putting the supply of brown powders for our larger calibers on a more satisfactory footing he found himself confronted by the records of a series of remarkably discrepant and apparently unaccountable results, particularly as respects the maximum pressures. For example: 400 pounds of lot 13 V P gave in the 12-inch gun a pressure of 36,000 pounds per square inch and a velocity of 1,932 foot seconds, and immediately after, 406 pounds gave 61,000 pounds and 2,006 foot seconds; with lot 4 V P in the same gun, 440 pounds gave 35,800 pounds and 1,959 foot seconds, while immediately following, 450 pounds gave 43,500 pounds and 1,970 foot seconds. Again, 342 pounds of lot 2 W U gave 33,000 pounds and 1,724 foot seconds, while the next charge of 350 pounds gave 65,000 pounds and 1,804 foot seconds; also, with the 10-inch gun 200 pounds of lot 8 V U gave 37,600 pounds and 1,813 foot seconds, while a charge of 200 pounds fired to verify this result gave 59,000 pounds and 1,843 foot seconds.

Nothing in the manufacture or character of the powders could be assigned as a probable explanation of these irregularities, and wave action was suggested as their cause. This suggestion was followed up and it may be fairly regarded as beyond question that these excessive pressures, as well as others complained of in your last annual report, were the result of wave action, which may, moreover, be controlled, at least in a great degree, by suitable conditions of loading and ignition. It will, perhaps, be of interest and benefit to set this matter forth in greater detail.

In the memorial des Poudres et Salpêtres, Tome III, 1890, there is a report by M. Vieille of some experiments made by him for the purpose of investigating the action of explosion gases in long tubes. The most instructive of these experiments were made with a tube about 3 feet long and about 1 inch in diameter, closed at both ends by pressure gauges. Three kinds of powder were used, of degrees of quickness suitable for muskets, siege guns, and the heaviest seacoast guns. The charges were disposed in three ways, uniformly distributed throughout the length of the tube, collected at one end, and one-half at each end, and the ignition was at one end, by means of an electric spark.

With the powder uniformly distributed, no wave action was observed up to the greatest densities of loading employed, which was 0.2 for the quicker powders and 0.25 for the slowest one. But with the charge disposed at one or both ends there always occurred a surging of the burned and burning charge from end to end, giving rise, at the ends where the surging mass was stopped and reflected, to pressures greater than those due to the tension of the gas uniformly distributed, and these excessive pressures were, in general, the same at both ends. The two quicker kinds gave abnormally excessive maximum pressures at densities of loading above 0.075 for the musket powder and 0.15 for the other, the former giving, with a density of loading of 0.2, a maximum pressure estimated at 107,000 pounds per square inch (it crushed the copper cylinder into a disk and bulged the stem of the pressure piston), or more than three times the normal pressure for that density

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of loading. With the slowest powder, the waves traveled back and forth while the powder burned and produced the ultimate compression of the copper cylinders by as many as 12 successive steps, separated by intervals of no increase of compression, but the maximum pressure did not, at the density of loading employed, exceed the normal pressure for that density. We may also infer from the trend of these results that abnormal pressures would have been obtained by the slowest powder at higher densities of loading, and that, with uniform distribution, end ignition at high densities of loading would probably produce similar results.

The conditions favorable to wave action appear to be length of chamber, quickness of the powder, high density of loading, ununiform distribution of the charge, and end ignition. In our system of large guns three of these conditions are always present, and it is probable that more or less wave action always occurs, though it may not result in abnormal maximum pressures. And when the charge does not occupy the whole length of the chamber abnormal results seem likely to occur, the more likely as the powder is quicker.

These considerations were brought to the attention of the commanding officer of the proving ground, and it then appeared that, although all charges were always made up to the full length of the chamber, it frequently occurred in the preliminary test of powder samples that a reduction of an already prepared charge became necessary, and in such cases the length only had been reduced and not the diameter. This was of course particularly likely to occur when the powder was too quick, the most unfavorable time. No records exist to show that the cartridges were short in the cases giving the very excessive pressures, except in one instance, that of lot 2 W U, cited above, but there is little room to doubt that they were the results of wave action induced by the shortness of the charge, assisted by too great quickness of the powder and the other favoring conditions. Since April the charges have always been made of the full length and no abnormally excessive pressures have occurred. It appears that with this precaution, even though the powder be too quick, this fact may be ascertained without excessive pressures and the test stopped in time to avoid them.

It is to be observed, however, that wave action would not greatly affect the average pressure or the velocity of the projectile, and that the pressures are most excessive in the direction of the axis of the bore. Their action on the walls of the gun being applied to but a small portion of the length of the wall, are less dangerous than pressures of equal magnitude covering the whole chamber. Their principal danger is that of derangement of the breech mechanism.

It has been stated above, as a corollary of the results obtained by Vieille, that end ignition would, when the other conditions were favorable, be likely to cause wave action which might be avoided by a more suitable method of ignition. In confirmation of this may be cited the firings of Troisdorf smokeless powder in the 3.2-inch field gun described and specially mentioned in your last annual report, in which firings excessive and irregular pressures were obtained in the gun with axial vent but not in that with radial vent. Also the experiments made for the purpose of ascertaining the relative merits of the axial and radial vents in the 3.2-inch field gun, using I K powder, described in your report for 1892.

Abnormal pressures occasionally occur with the seacoast guns firing brown powder under normal conditions of loading, but it is believed that they are never sufficient to endanger the working of the breech

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mechanism, and as the velocity of the projectile is but little affected by them, they are not of much practical importance. They indicate, however, that the normal conditions in the chamber border closely on the region of excessive wave-action, and, taken with the highly excessive pressures likely to arise from the use of cartridges of reduced length, suggest the necessity of a general recognition of this danger, which is, moreover, deemed sufficient to warrant the issue of stringent regulations on this point concurrently with the issue of the new armament to the service.

BROWN POWDERS.

The ballistic qualities at present considered as standard for these powders in our service cannon are as follows:

Piece.	Charge.	Projectile.	Limiting pressure per square inch.	Muzzle velocity.
	Pounds.	*Pounds.*	*Pounds.*	*Ft. secs.*
8-inch B. L. rifle, steel	125	300	37,000	1,975
10-inch B. L. rifle, steel	245	575	37,000	2,000
12-inch B. L. rifle, steel	450	1,000	37,000	1,975
12-inch B. L. mortar, steel	105	800	31,000	1,140
12-inch B. L. mortar, cast iron-hooped	80	800	27,500	1,020

NOTE.—The same powder for both mortars.

It is believed that, with the advantage afforded by the ability to test the powders in the 8-inch gun here concurrently with the manufacture, in order to regulate their quickness, that the Du Pont Company will be able to produce the powders for the 8-inch and 10-inch guns and the mortars with practical certainty, and that they can do better with the 8-inch powder, although occasional trouble may be experienced in obtaining 2,000 foot seconds with the 10-inch gun.

But the conditions respecting the production of satisfactory powder for the 12-inch gun are not so favorable. Much improvement will undoubtedly be experienced in the regularity of the powder as regards quickness, but there is a fundamental difficulty of another nature to be overcome in order to meet the requirements specified above. The method hitherto employed to reduce the quickness of brown powder also reduces in some degree the force, so that, even with the quickness suitably regulated, it would rarely, if ever, give so high a velocity as stated above. The company is, however, energetically endeavoring to produce a method by which this reduction of force may be avoided, but it is yet too early to predict success or failure.

SMOKELESS POWDERS.

This office has had little occasion for action in this domain since its establishment. The small-arms powder is being developed at Frankford Arsenal, and powders for the other calibers had scarcely been taken up at the end of the fiscal year. Since that time specifications for samples for the 5-inch and 7-inch siege pieces and the 8-inch and 10-inch guns have been prepared. The requirements of these specifications for acceptance are only such as can be fulfilled by a number of powders already in existence, and it is hoped that the proposals for bids will meet with a response that will establish a good basis for the processes of elimination and improvement.

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A few general remarks regarding the present status of the question from our point of view may be admissible. The two prominent classes or types between which the rivalry seems to be well established are the so-called nitrocotton and nitroglycerine types, the former having nitrocotton as its base, and the latter containing more or less nitroglycerine in that capacity. Each has its relative advantages and disadvantages, and it is probable that neither will entirely displace the other, but that each will find a field for its particular good qualities. The second-named type appears to possess the greater force and to give the better ballistic results, but at the expense of greater erosion. As to stability, nitroglycerine is ordinarily more stable than nitrocotton, but the tendency of nitroglycerine to exude from the powders containing it appears to quite offset this advantage. These appear to be the fundamental relative advantages of the two types. The fundamental questions at issue between them, to be decided for each particular piece, are which gives the requisite ballistic results with the less erosion, or the greater ballistic results with allowable erosion, and which presents, in the form adapted to the ballistic requirements, the greater stability. Of course various minor considerations arise, but these are the elementary ones.

For small arms the condition of high projectile energies and small charges favor the nitroglycerine type, and the Peyton powder of this type appears to have the lead in this country at present. It is being delivered for current use at Frankford Arsenal, and appears to meet the arsenal tests and requirements satisfactorily. The tests of use in service and long storage still await it. It is, however, probable that satisfactory ballistics may also be obtained with powders of the other type, and the question between the two can not be regarded as settled.

For field and siege guns the projectile energies are limited by conditions of recoil, and are easily accessible by powders of both types with allowable erosions. For these classes and small-arms powders domestic or foreign already exist which would meet the necessary requirements of service, so that the question is already reduced to a balancing of advantages, and at least a good, if not the ultimate, solution, seems to be assured at an early date.

With powders for the seacoast guns the case is different. The large charges required for these guns produce great erosions, so that it is as yet questionable whether this consideration may not prohibit their use except in actual action. The requirement of high projectile energies seems to demand the nitroglycerine type, while, on the other hand, the greater erosions produced by it seem almost prohibitory, and which of the two types will succeed in bringing the erosions within allowable limits while producing satisfactory velocities it is quite impossible to predict. For both types, in all classes of guns, the question of stability in storage is as yet unsolved, at least by us or to our satisfaction.

INSPECTION OF POWDER AT THE DU PONT POWDER WORKS.

During the fiscal year the following-named contracts and orders have been in hand at these works:

Contract dated April 26, 1892, for 148,200 pounds brown prismatic powder for 10-inch and 12-inch B. L. rifles, steel.

Contract dated April 18, 1893, for 40,000 pounds brown prismatic powder for 12-inch B. L. mortars.

Contract dated February 17, 1894, for 75,000 pounds brown prismatic powder for 10-inch B. L. rifles.

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Contract dated June 18, 1894, for 16,000 pounds sphero-hexagonal powder for field guns.

Contract with Frankford Arsenal, dated July 18, 1893, for annual supply of small-arms powder, black.

Order from Sandy Hook Proving Ground, dated January 26, 1894, for 8,760 pounds brown prismatic powder for the 5-inch Brown segmental gun.

Order from Sandy Hook Proving Ground, dated March 23, 1894, for 32 pounds mealed powder and 200 pounds F F gunpowder.

Order dated April 14, 1894, for 100 pounds T W cubical powder for Hotchkiss 3-pounder R. F. gun, for West Point.

Order from Frankford Arsenal, dated June 11, 1894, for 2,000 pounds H N mortar powder for 1.65-inch Hotchkiss mountain gun.

Of the 148,200 pounds called for by the contract of April 26, 1892, there was delivered during the fiscal year 15,098½ pounds for the 8-inch B. L. rifle, steel, 39,948¾ pounds for the 10-inch B. L. rifle, steel, and 15,499 pounds for the 12-inch B. L. rifle, steel, a total of 70,546¼ pounds. There remain to be delivered 61,414½ pounds. The proof tests of these 8-inch and 10-inch powders have been on the whole very satisfactory. That of the lot of 12-inch powder was not so, but the lot was accepted, as it was urgently needed for certain purposes for which it would do.

There was delivered under the contract for 12-inch mortar powder 30,040¾ pounds. The execution of the remainder of this contract is held in abeyance at the request of the Department.

The contract of February 17, 1894, originally called for powder for the 10-inch Woodbridge steel gun, but upon the failure of the tube of the gun, after the delivery of 18,105½ pounds, the remainder was by mutual consent converted into 15,000 pounds for the 10-inch B. L. rifle, steel, and 41,894½ pounds for the 10-inch B. L. rifle, Crozier, all of which remains undelivered.

The lining tube of the Brown gun failed after 7,372½ pounds had been delivered, and the remainder was countermanded.

The sphero-hexagonal powder called for by the contract of June 11, 1894, was not delivered till after the close of the fiscal year, but it is included in this report as naturally pertaining thereto. It was desired that the powder should be suitable for use in both the 3.2-inch and 3.6-inch guns, with 3½ pounds charge in the light and 4 pounds 3 ounces in the heavy gun. This condition has never been fulfilled, it is believed, even in experimental firing, 4 pounds 6 ounces being usually required in the latter gun. In the present case a charge of 4 pounds 5 or 6 ounces was found to be suitable.

The remark respecting the delivery of the sphero-hexagonal powder applies also to the H N powder for the Hotchkiss mountain gun. It was desired to obtain a powder that would give the standard velocity of 1,300 foot seconds and just fill the cartridge case. The conditions were fulfilled with a 5½-ounce charge of gravimetric density 970, as determined by pouring slowly into a graduated glass bottle about 1 inch in diameter and 12 inches high.

The following table shows the requirements as to proof and the results obtained on the acceptance proof for the various lots delivered:

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Date of order or contract.	Lot of powder.			Proof.				
	Kind.	Designation.	Weight.	Gun.	Charge.	Projectile.	Pressure per square inch.	Muzzle velocity.
			Pounds.		*Pounds.*	*Lbs.*	*Pounds.*	*Ft. secs.*
Apr. 26, 1892.	Brown prismatic.	Requirement.		8-inch B. L. rifle, steel.	125	300	37,000	1,950
....do		5 U R.	15,098½	....do	125	300	36,000	2,025
....do		Requirement.		10-inch B. L. rifle, steel.	245	575	37,000	1,975
....do		13 V U.	503	....do	240	575	36,200	1,956
....do		16 V U.	14,789½	....do	240	575	37,500	1,990
....do		17 V U.	14,856	....do	243	575	36,000	1,931
....do		4 W H.	9,800	....do	245	575	36,500	1,998
....do		4 W H.	.....	10-inch Woodbridge	246	577	39,700	1,995
....do		Requirement		12-inch B. L. rifle, steel.	450	1,000	37,000	1,975
....do		W Q ..	15,499	... do	450	1,000	39,000	1,907
Apr. 18, 1893.	....do	Requirement.		12-inch B. L. mortar, steel.	105	800	31,000	1,140
....do		Requirement.		12-inch B. L. mortar, cast iron.	80	800	27,500	1,020
....do		6 V M.	13,563½	12-inch B. L. mortar, steel.	100	812	31,000	1,145
....do		6 V M.	.....	12-inch B. L. mortar, cast iron.	73	800	28,500	1,033
....do		7 V M.	16,477	12-inch B. L. mortar, steel.	78	807	22,000	1,000
....do		7 V M.	.....	12-inch B. L. mortar, cast iron.	72	800	27,000	1,005
Feb. 17, 1894.	....do	Requirement.		10-inch Woodbridge	250	575	40,000	2,000
....do		3 W H.	2,576½	....do	271	568	37,500	2,085
....do		7 W H.	15,528½	....do	245	575	44,000	2,110
....do		Requirement.		10-inch B. L. rifle, steel.	245	575	37,000	2,000
....do		Requirement.		10-inch B. L. rifle, Crozier.	254	575	42,000	2,140
Jan. 26, 1894.	....do	Requirement.		5-inch Brown segmental.	30	60	40,000	2,200
....do		W V...	7,372½	....do	36.56	61	41,000	2,200
June 18, 1894.	Sphero-hexagonal.	Requirement.		3.2-inch field gun ..	3.5	13.5	35,000	1,670
....do		Requirement.		3.6-inch field gun ..	4.19	20	35,000	1,540
....do		23 U F.	16,000	3.2-inch field gun ..	3.5	13.5	33,900	1,673
....do		23 U F.	.....	3.6-inch field gun ..	4.31	20	33,600	1,540
					Ounces.			
June 11, 1894.	Mortar	2 H N.	2,000	1.65 Hotchkiss mountain gun.	5½	2	.....	1,317
					Grains.			
July 18, 1893.	Musket.....	Requirement.		Springfield, .45-caliber.	69	500	30,000	1,260
	(Black)	F F g, lot 8.	10,000	....do	69	500	22,040	1,279
....do		F F g, lot 9.	10,000	....do	69	500	20,352	1,273
....do		F F g, lot 10.	10,000	....do	69	500	25,900	1,289
....do		F F g, lot 11.	10,000	....do	69	500	26,400	1,285
....do		F F g, lot 1–7.		Tested at Frankford Arsenal.				

The character of the firm of E. I. Du Pont de Nemours & Co., and the reliability of their work, as established by an unbroken connection of more than eighty years with the Ordnance Department, render the detail of an officer at their works for the sole purpose of inspecting the powder furnished by them of little necessity or benefit. The usefulness of such a detail is to be found in the fact that important questions respecting the production and adoption of suitable powders for our new armament, especially of the brown and smokeless types, are demanding solution and settlement. It is in this direction that the efforts of this office are deemed to be principally due and most usefully directed.

Very respectfully, your obedient servant,

SIDNEY E. STUART,

Captain, Ordnance Department, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY.

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APPENDIX 24.

PROGRESS REPORT OF MANUFACTURE OF STEEL FORGINGS, ETC., AT MIDVALE STEEL WORKS, PHILADELPHIA, PA., DURING THE FISCAL YEAR ENDED JUNE 30, 1894.

MIDVALE STEEL WORKS,
Philadelphia, Pa., September 1, 1894.

SIR: I have the honor to transmit the following report upon the operations undertaken for the Ordnance Department, U. S. Army, by the Midvale Steel Company, for the fiscal year ending June 30, 1894.

All information relative to manufacture is omitted from this report upon the request of the Midvale Steel Company. The right to make this request is granted in the specifications embodied in the contracts, and all information given by the company is to be considered as confidential, and for the use of the Department only.

List of fabrications.

STEEL FORGINGS.

Fabrication.	Number of contract.	Date of order or contract.	Date of expiration of contract or extension of contract.
9 sets of steel forgings for 12-inch B. L. rifle	1	June 15, 1891	Aug. 16, 1896
14 sets of steel forgings for 10-inch B. L. rifle	2	....do	Aug. 16, 1894
9 sets of steel forgings for 8-inch B. L. rifle	3	June 22, 1893	Feb. 19, 1894
218 8-inch A. P. shot (extended to Dec. 6, 1892)	4	Dec. 13, 1890	Dec. 13, 1891
217 8-inch A. P. shot (extended to Dec. 6, 1892)	5	....do	June 5, 1892
100 8-inch A. P. shot	6	June 8, 1891	Mar. 11, 1892
205 10-inch A. P. shot	7	....do	Dec. 4, 1892
50 12-inch A. P. shot	8	....do	Aug. 1, 1892
98 12-inch A. P. shot	9	Oct. 15, 1892	Apr. 8, 1894
6 12-inch mortar deck-piercing shell	10	Jan. 26, 1893	(*)

* Midvale own order.

MISCELLANEOUS STEEL FORGINGS.

1 tube for 8-inch B. L. rifle	11	May 25, 1893	Immediate.
1 jacket for 10-inch B. L. rifle	12	Nov. 7, 1893	Do.
1 hoop C_4 for 10-inch B. L. rifle	13	Jan. 6, 1894	Do.
1 hoop A_3 for 10-inch B. L. rifle	14	Jan. 12, 1894	Do.
1 jacket for 10-inch B. L. rifle	15	Jan. 31, 1894	Do.
1 hinge block for 12-inch B. L. R. mortar	16	Feb. —, 1894	Do.
1 face plate for 12-inch B. L. R. mortar	17	Feb. 2, 1894	Do.
1 hoop C_6 for 10-inch B. L. rifle	18	Feb. 17, 1894	Do.
1 hoop C_5 for 10-inch B. L. rifle	19	....do	Do.
1 hoop C_2 for 8-inch B. L. rifle	20	Apr. 21, 1894	Do.
1 spindle for 10-inch B. L. rifle; 1 spindle for 12-inch B. L. rifle	21	May 8, 1894	Do.
1 hoop B_6 for 10-inch B. L. rifle	22	May 22, 1894	Do.
1 hoop C_1 for 8-inch B. L. rifle	23	May 28, 1894	Do.
1 hoop C1 for 8-inch B. L. rifle	24	....do	Do.
2 hoops C_1 for 8-inch B. L. rifle	25	June 21, 1894	Do.
1 hoop B_4 for 10-inch B. L. rifle	26	....do	Do.
1 tube for 10-inch B. L. rifle	27	June 22, 1894	Do.
Do	28	June 29, 1894	Do.
1 jacket for 10-inch B. L. rifle	29	July 5, 1894	Do.
1 hoop C_1 for 8-inch B. L. rifle	30	....do	Do.

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List of fabrications—Continued.

STEEL CASTINGS.

Fabrication.	Number of contract.	Date of order or contract.	Date of expiration of contract or extension of contract.
3 12-inch barbette top carriages	31	Mar. 2, 1893	Immediate.
6 12-inch cheeks	32		
3 12-inch upper roller paths	33		
1 breech plate for 10-inch B. L. rifle	34	Mar. 6, 1894	Do.
19 castings for gun-lift carriage for 12-inch B. L. rifle, viz: 3 top carriages, 6 cheeks, 3 front transoms, 3 upper roller paths, 2 front racer clips or guide hooks, 2 rear racer clips or guide hooks.	35	Jan. 25, 1894	June 17, 1894

Of the above list the following numbers have been completed: Nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 31, 32, 33, and 34. The stores represented by these numbers have been shipped to their respective destinations.

The unfinished work at the date of this report comprises Nos. 1, 22, 25, 26, 27, 28, 29, 30, and 35.

No work has yet been submitted for test from Nos. 22, 25, 26, 27, 28, 29, and 30.

The work under Nos. 1 and 35 is in progress at the date of this report.

References to the finished and unfinished work will be found below under appropriate headings:

I.—12-INCH B. L. RIFLES, MODEL 1888.

TABLES.

This contract is for 9 guns. The forgings for the breech mechanism have all been shipped except the breech blocks, which have been accepted as to physical qualities.

The following hoops have been forged for this contract, viz: 2 hoops C_1, 2 hoops C_2, 9 hoops C_3 (6 condemned), 3 hoops A_1, and 3 hoops A_2.

The necessary plant has been nearly completed for manufacture of the 12-inch B. L. rifle forgings. The company expect to push this work to completion at the earliest possible moment.

II.—8-INCH AND 10-INCH B. L. RIFLES.

TABLES A AND B.

All the forgings for the 8 and 10 inch B. L. rifles for which contracts were made have been finished and shipped to Watervliet Arsenal. There remain, however, some forgings for these pieces which must be made to replace those condemned for defects developed during machining.

A number of replacements have been made during the year, but they call for no special remark.

III.—ARMOR-PIERCING PROJECTILES.

The Midvale Steel Company have completed all their contracts for armor-piercing projectiles.

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The company made 5 12-inch mortar deck-piercing projectiles at their own expense, 2 of which were condemned and 3 shipped to Sandy Hook, N. J.

The 12-inch, 10-inch, and 8-inch A. P. shot were shipped to Watervliet Arsenal for banding, except those intended for ballistic tests. The latter were sent to the ordnance proving ground at Sandy Hook, N. J

(*a*) 12-INCH ARMOR-PIERCING PROJECTILES.

	No. of shot.
Required by contract of October 15, 1892	98
Required by contract of June 8, 1891	50
Total contract for	148
Total accepted, contract October 15, 1892	109
Total accepted, contract June 8, 1891	50
Total accepted	159

(*b*) 10-INCH ARMOR-PIERCING PROJECTILES.

Required by contract of June 8, 1891	205
Required by contract of December 13, 1890	217
Total contracted for	422
Total accepted, contract of June 8, 1891	213
Total accepted, contract of December 13, 1890	217
Total accepted	430

(*c*) 8-INCH ARMOR-PIERCING PROJECTILES.

Required by contract of June 8, 1891	100
Required by contract of December 13, 1890	218
Total contracted for	318
Total accepted, contract of June 8, 1891	103
Total accepted, contract of December 13, 1890	218
Total accepted	221

IV.—STEEL CASTINGS.

TABLES.

(1) *12-inch barbette carriage.*—The roller path unfinished at date of last report has been finished and shipped to Watertown Arsenal.

(2) *Breech plate for 10-inch B. L. rifle.*—This casting was made to replace a defective one sent to Watervliet Arsenal. Test of 10-inch breech plate (Midvale, No. 34089). Tensile strength, 75,600; elastic limit, 36,000; elongation, 25.30.

(3) *Gun lift for 12-inch B. L. rifle.*—There are 19 castings for this gun lift. Eleven castings have been shipped to Watertown Arsenal, viz, 6 cheeks, 3 front transoms, 2 rear racer clips or guide hooks.

V.—OUTSIDE WORK.

TABLE D.

In addition to the work at the Midvale Steel Works, the inspector here has had charge of the inspection of carriage material at the Benj. Atha & Illingworth's works at Newark, N. J., and at the Penn Steel Casting Company at Chester, Pa.

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The latter company have begun work upon their contract for five sets of castings for 10-inch barbette carriages, none of which have yet been submitted for test.

The Atha & Illingworth Company have completed the work for 12-inch mortar spring return carriage, noted in my last progress report (pp. 427 to 429, Report of Chief of Ordnance, U. S. Army, for 1893), and in addition have supplied Rock Island Arsenal with a lot of castings and forgings for siege carriages, except a small lot of Swedish iron not yet delivered. Capt. Charles S. Smith, Ordnance Department, had charge of and completed this work during my absence.

During the past year the Midvale Steel Company undertook to furnish a lot of material for the lock gates on the St. Marys Canal, now being constructed under the direction of Col. O. M. Poe, Corps of Engineers, U. S. Army.

As this was United States work, and could be easily looked after by a resident inspector, this office took charge of it.

The Midvale Steel Company have just completed the work, upon which a special report will shortly be submitted by my engineer assistant, Mr. O. W. Albee.

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TABLE A.—PARTS OF 10-INCH B. L. RIFLE.

Name of piece.	Tested.		Maximum.				Mean.				Minimum.			
	Number of pieces.	Number of bars.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elon gation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.
Tubes	12	72	58,000	95,280	28.80	57.40	45,614	82,406	21.65	39.80	41,000	76,000	16.00	19.60
Jackets	14	84	58,000	105,200	26.30	57.00	48,990	88,352	20.44	39.04	40,000	80,800	13.10	22.00
Trunnion hoops	11	33	63,000	104,000	21.00	56.03	56,940	98,551	18.70	48.24	49,000	94,000	16.80	33.20
Hoops A_1	6	17	63,000	104,400	21.00	44.50	55,000	98,130	16.85	33.80	51,000	93,200	12.10	16.74
A_2	5	15	61,000	105,200	19.70	48.20	53,738	97,838	16.54	40.99	51,000	93,200	13.00	30.80
A_3	7	21	61,000	108,800	19.20	56.50	56,000	100,105	15.71	36.07	51,000	93,200	12.40	23.60
A_4	5	15	63,000	115,600	23.00	51.90	57,222	102,071	16.54	36.90	50,000	93,600	13.20	23.58
A_5	13	39	66,000	107,600	22.80	54.60	56,154	99,175	16.66	38.18	51,000	92,800	13.30	25.13
B_2	8	24	63,000	106,800	19.80	51.45	57,060	100,640	15.42	34.10	51,000	93,200	12.20	18.20
B_3	6	18	64,000	108,000	21.90	52.40	56,300	101,411	15.63	33.60	50,000	93,200	13.00	26.05
B_4	14	42	64,000	106,800	23.00	55.10	54,834	98,433	16.30	36.40	50,000	93,000	12.40	19.20
C_1	12	36	63,000	102,400	21.20	46.10	54,700	97,309	17.74	35.04	50,000	93,600	15.00	17.30
C_2	12	36	63,000	104,800	21.70	50.00	57,194	98,733	17.19	35.92	53,000	94,800	16.60	29.40
C_3	2	6	59,000	100,000	22.20	51.50	58,666	98,000	19.79	44.23	54,000	95,600	15.60	36.90
C_5	3	9	64,000	109,200	21.70	57.90	58,888	102,000	18.13	43.12	54,000	93,600	15.30	29.10
D_1	12	36	65,000	105,600	23.30	51.00	55,306	96,725	17.65	32.77	52,000	93,200	13.10	15.30
D_2	13	39	72,000	116,000	22.50	52.90	57,600	97,630	18.15	38.40	52,000	93,200	12.40	23.27
Spindles	1	1	57,000	97,600	19.73	43.75	57,000	97,600	19.73	43.75	57,000	97,600	19.73	43.75
Locking rings	1	3	63,000	105,200	19.57	46.12	60,000	102,738	18.02	42.56	58,000	101,600	16.20	39.96

TABLE B.—PARTS OF 8-INCH B. L. RIFLE.

Tubes	9	53	53,000	89,200	26.20	55.80	46,434	83,081	21.21	41.46	42,000	79,800	16.00	24.50
Jackets	9	54	59,000	98,600	25.30	53.90	51,333	89,485	20.46	41.12	43,000	84,800	13.60	20.15
Trunnion hoops	10	30	64,000	102,800	23.00	56.96	54,600	97,093	19.26	49.66	50,000	92,400	16.00	32.61
Hoops A_1	5	15	60,000	100,400	20.50	51.50	55,600	96,653	19.00	38.91	51,000	93,600	16.00	29.07
A_2	9	27	64,000	101,200	24.30	54.60	55,900	99,888	18.73	37.77	51,000	92,000	13.40	16.94
A_4	9	28	63,000	106,000	21.60	50.00	57,358	99,000	17.62	34.43	53,000	95,200	13.00	14.70
C_1	9	27	67,000	105,600	24.10	53.90	58,240	98,244	17.88	38.00	52,000	93,600	12.00	13.68
C_2	10	30	67,000	106,000	22.40	57.00	56,900	99,153	18.26	38.46	52,000	92,800	15.20	27.87
D	9	27	65,000	108,000	20.90	55.10	56,408	95,350	17.47	35.11	52,000	92,800	14.10	25.40
Breech bushing rings	3	6	60,000	105,500	22.30	40.34	55,500	98,750	20.90	35.74	52,000	93,000	18.70	28.85
Breech blocks	5	5	52,000	92,000	23.40	55.10	48,400	87,880	20.80	48.03	46,000	85,000	19.10	44.54
Gas-check cups	5	10	86,000	141,200	15.00	37.47	82,500	139,520	12.96	33.47	80,000	138,000	11.70	30.25
Spindles	5	5	59,000	97,500	25.70	51.12	54,200	92,500	22.40	42.24	48,000	85,000	16.40	23.41
Rotating rings	2	2	51,000	92,400	21.80	57.97	50,500	90,200	20.25	56.02	50,000	88,000	18.70	54.84
Shoulder rings	1	3	57,000	100,000	22.80	55.32	55,700	94,933	19.40	44.46	55,000	96,000	16.40	29.37
Securing pins	2	2	94,000	144,000	14.50	35.78	93,000	143,100	13.75	34.60	92,000	142,200	12.50	33.48
Hinge pins	2	2	61,000	99,200	23.20	64.49	57,500	93,400	22.50	61.41	54,000	87,600	21.80	58.34

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Summary of tests, steel castings, Midvale Steel Company, Philadelphia, Pa.

Material.	Tested.		Maximum.				Mean.				Minimum.			
	Number of pieces.	Number of bars.	Elastic limit.	Tensile strength.	Elongation.	Contraction.	Elastic limit.	Tensile strength.	Elongation.	Contraction.	Elastic limit.	Tensile strength.	Elongation.	Contraction.
8-inch barbette carriage	4	7	39,000	77,250	27.60	50.00	36,214	76,072	24.63	38.42	35,000	75,500	15.30	20.22
12-inch barbette carriage	5	8	39,500	79,000	28.20	43.50	36,188	76,250	25.48	38.70	32,500	72,500	22.80	36.30
12-inch gun lift	16	34	38,000	82,500	36.80	56.30	34,638	74,850	25.84	38.56	31,500	67,000	16.80	18.80
Miscellaneous	6	6	40,500	83,000	29.00	46.60	36,666	77,167	24.71	38.00	32,000	75,500	16.20	14.13

TABLE C.—*Parts furnished by Midvale Steel Company.*

WEIGHTS OF FORGINGS.

Designation.	Aggregate weight.
	Pounds.
10-inch B. L. rifle	1,003,000
8-inch B. L. rifle	356,336
12-inch A. P. shot	158,364
10-inch A. P. shot	245,960
8-inch A. P. shot	95,337
Miscellaneous forgings	120,827
Total	1,979,824
St. Marys Canal gate forgings	302,863
Total	2,282,687

WEIGHTS OF STEEL CASTINGS.

12-inch gun-lift castings	97,822
12-inch barbette carriage castings	21,936
8-inch barbette carriage castings	26,849
Miscellaneous	979
Total	147,586

Number of pieces shipped:	
10-inch B. L. rifle	226
8-inch B. L. rifle	154
8, 10, and 12 inch A. P. shot	900
St. Marys Canal forgings	306
Miscellaneous forgings	892
Miscellaneous castings	53
Total	2,533

TABLE D.—*Results of tests of steel castings.*

[Benj. Atha & Illingworth Company, Newark, N. J.]

12-inch mortar, spring return carriage.	Number of bars tested.	Maximum.				Mean.				Minimum.			
		Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.	Elastic limit.	Tensile strength.	Elongation.	Contraction of area.
Hydraulic cylinders	150	49,500	91,500	28.80	43.70	39,076	70,900	17.10	19.60	34,500	70,500	10.30	11.10
Trunnion carriages	102	44,000	82,500	30.20	42.50	38,691	73,471	18.40	23.21	31,500	64,000	8.00	13.20
Rollers, forgings	22	61,500	105,500	22.50	42.78	55,500	97,523	19.83	35.63	48,500	91,000	17.50	31.50

Number of tests (castings)	568
Number of tests (forgings)	76
Total	644

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I was absent from my station on leave of absence on surgeon's certificate of disability from February 16, 1894, to August 15, 1894, and during this time Capt. Charles S. Smith, Ordnance Department, U. S. Army, had charge of the work at this place as inspector.

Respectfully submitted.

D. A. LYLE,
Captain, Ordnance Department, U. S. Army, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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APPENDIX 25.

PROGRESS REPORT ON MANUFACTURE OF STEEL FORGINGS, ETC., AT BETHLEHEM IRON WORKS.

OFFICE OF INSPECTOR OF ORDNANCE, U. S. ARMY,
Bethlehem Iron Works, South Bethlehem, Pa., July 24, 1894.

SIR: I have the honor to submit the following report of the progress during the fiscal year ending June 30, 1894, of the work ordered by the Ordnance Department to be made under the supervision of the inspector of ordnance at these works:

The Bethlehem Iron Company has been manufacturing forgings under the following contracts or orders, viz:

(1) For fifteen 12-inch B. L. rifles, contract of January 31, 1889.
(2) For seven 12-inch B. L. mortars, contract of September 26, 1892.
(3) For twelve 10-inch B. L. rifles, contract of September 26, 1892.
(4) For ten 12-inch B. L. rifles, contract of September 26, 1892.
(5) For seven 10-inch B. L. rifles, contract of June 24, 1893.
(6) For one 12-inch B. L. rifle, model 1892, contract of June 24, 1893.
(7) For seven 12-inch B. L. rifles, contract of June 24, 1893.
(8) For miscellaneous pieces.

They have also been carrying on the manufacture, under contract of November 7, 1891, of 100 B. L. rifles of 8, 10 and 12 inch calibers.

(1) FORGINGS FOR 12-INCH B. L. RIFLES.

This contract was completed October 27, 1893, by the delivery of 5 sets after the close of the last fiscal year.

(2) FORGINGS FOR TWELVE 10-INCH B. L. MORTARS.

The delivery of a bushing, jacket, and gas check cups by August 29, 1893, completed this contract.

(3) FORGINGS FOR TWELVE 10-INCH B. L. RIFLES.

This contract was completed December 23, 1893.

(4) FORGINGS FOR TEN 12-INCH B. L. RIFLES.

Five complete sets have been delivered, but work is progressing on parts of other sets.

(5) FORGINGS FOR SEVEN 10-INCH B. L. RIFLES.

Five sets have been delivered, and the remainder are in part delivered and part under way.

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(6) FORGINGS FOR ONE 12-INCH B. L. RIFLE, MODEL 1892.

This set was delivered June 21, 1894.

(7) FORGINGS FOR SEVEN 12-INCH B. L. RIFLES.

No complete sets have yet been delivered, but many pieces are furnished or in progress of manufacture.

(8) MISCELLANEOUS FORGINGS.

Three bands for Haskell multicharge gun, delivered July 28, 1893.
One band for Haskell multicharge gun, delivered March 9, 1894.
One 3.6-inch B. L. mortar spindle, delivered October 17, 1893.
One 12-inch mortar face plate, delivered December 12, 1893.
One 12-inch trunnion hoop, delivered May 31, 1894.
The latter two were to replace defective forgings which had been accepted and shipped.

MANUFACTURE OF TWENTY-FIVE 8-INCH, FIFTY 10-INCH, AND TWENTY-FIVE 12-INCH B. L. STEEL RIFLES.

Forgings for ten 8-inch and six 10-inch rifles have been accepted for physical qualities. Fair progress is being made in the assembling of the 8-inch. Two have all of the hoops shrunk on, 1 is ready for the shrinkage of the A hoops, 2 have the D hoop in position, and 1 is turned for the D hoop. Four tubes are bored and being prepared for shrinkage of jacket. This makes 10 guns which are in hand, and the breech mechanism for these is well under way.

But little work has been done on the 10-inch rifles beyond the preliminary boring of 4 tubes and finish boring of the same number of each of the hoops. Six jackets have been rough-turned, but none is as yet bored.

No work has been commenced on parts of the 12-inch rifles.

Under contract of August 7, 1893, the Carpenter Steel Company, of Reading, Pa., has been manufacturing 100 12-inch steel armor-piercing shot. The entire number, including those necessary for ballistic trial, have been completed and passed the inspection for dimensions and weight satisfactorily, but the first two lots of 25 each failed to meet the requirements of the ballistic test. The other two lots have not so far been presented for this test.

The Reading Iron Company, of Reading, Pa., presented for final inspection in May the 8-inch Haskell multicharge gun, which they were under contract of June 8, 1891, to manufacture. The gun being satisfactorily completed in accordance with the requirements of the contract, it was accepted on May 31, 1894, and has been shipped to the Sandy Hook Proving Ground.

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Designation of piece.	Number of pieces.	Average. Elastic limit per square inch of original section.	Tensile strength per square inch of original section.	Elongation after rupture.	Reduction in area after rupture.
		Pounds.	*Pounds.*	*Per cent.*	*Per cent.*
8-inch tubes	6	50,480	90,110	21.2	48.2
8-inch jackets	6	51,140	91,290	21.2	48.3
8-inch trunnion hoops	11	56,530	103,720	17.3	44.3
8-inch A hoops	20	58,200	100,450	19.5	48.2
8-inch C hoops	18	57,990	101,000	17.7	43.4
8-inch D hoops	9	58,160	101,460	19.4	44.4
8-inch breech bushing	2	58,100	100,780	20.4	40.4
8-inch breech blocks	5	48,400	90,000	19.4	39.8
8-inch spindles	5	51,530	91,948	24.9	51.8
8-inch hinge pins	2	53,500	91,400	23.2	52.7
8-inch gas-check cups	1	81,500	155,800	10.0	21.1
10-inch tubes	26	48,810	88,990	21.6	48.5
10-inch jackets	19	50,940	90,510	21.1	47.6
10-inch trunnion hoops	13	57,200	101,720	17.9	47.7
10-inch A hoops	55	59,620	103,900	17.1	47.3
10-inch B hoops	34	59,240	103,420	17.3	47.3
10-inch C hoops	43	58,570	100,120	18.7	43.9
10 inch D hoops	26	59,520	102,930	18.5	44.2
10-inch breechblocks	7	49,170	90,600	20.5	40.5
10-inch spindles	5	54,000	96,680	20.0	43.1
10-inch hinge pins	3	62,700	98,400	23.1	59.3
10-inch securing pins	8	88,000	149,550	13.5	37.6
10-inch gas-check cups	6	86,000	151,870	12.3	30.6
12-inch tubes	10	45,740	89,690	22.2	47.2
12-inch jackets	8	45,950	91,220	21.5	45.7
12-inch trunnion hoops	8	57,280	104,700	17.2	44.2
12-inch A hoops	44	58,740	102,900	17.1	47.4
12-inch B hoops	24	57,780	101,360	17.6	48.8
12-inch C hoops	30	59,000	101,970	18.5	44.8
12-inch D hoops	15	57,680	101,510	17.2	47.2
12-inch breech bushing	1	61,330	104,530	19.1	44.5
12-inch breechblocks	9	49,830	89,300	21.0	42.9
12-inch spindles	9	49,450	89,470	20.9	45.8
12-inch hinge pins	5	60,800	102,400	21.6	55.5
12-inch securing pins	4	82,500	144,100	15.1	42.6
12-inch gas-check cups	5	81,400	144,800	13.0	29.3
12-inch tube (nickel steel)	1	54,800	104,700	17.2	44.2
12-inch mortar jacket	1	47,125	90,175	20.0	48.6
12-inch mortar breech bushing	1	59,000	100,930	19.6	44.8
12-inch mortar gas-check cup	1	82,000	145,000	11.4	23.2

The above table, giving the average physical qualities of specimens tested, shows the continued production of material of excellent quality. In the 8 and 10 inch tubes and jackets quite a decided increase of elastic limit is observed over that of previous years. Most all of the hoops, of all calibers, though retaining the same high elastic limit, have shown a slight diminution of tensile strength and an increase in elongation after rupture.

The weights of forgings shipped during the year are as follows:

Forgings for—	Weight.
10-inch B. L. rifles	1,067,102
12-inch B. L. rifles	1,897,773
12-inch B. L. mortars	13,937
Miscellaneous	6,501
Total	2,985,313

Very respectfully, your obedient servant,

I. MACNUTT,
Captain, Ordnance Department, U. S. Army, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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APPENDIX 26.

PROGRESS REPORT ON MANUFACTURE OF ORDNANCE AT WEST POINT FOUNDRY.

OFFICE OF INSPECTOR OF ORDNANCE, U. S. ARMY,
WEST POINT FOUNDRY,
Cold Spring, N. Y., July 1, 1894.

SIR: I have the honor to submit the following report of the operations of the Ordnance Department at the West Point Foundry during the fiscal year ended June 30, 1894:

Shipments to Sandy Hook, N. J., under contract with the West Point Foundry Company, dated December 5, 1890, for eleven 8-inch steel B. L. rifles were made as follows:

Guns Nos. 6 and 7, July 18, 1893; gun No. 8, October 17, 1893; gun No. 9, November 20, 1893; guns Nos. 10 and 11, December 6, 1893.

The original contract expired June 5, 1894, but owing to the delay in receipt of templets from the Department, corrections in drawings, and other causes an extension to November 1, 1894, was granted.

The last gun was completed and delivered at the Sandy Hook Proving Ground December 9, 1893, thus completing the contract six months before the expiration of the original time.

Four 15-inch pneumatic dynamite guns have been completed at these works during the past fiscal year. Two were shipped to Sandy Hook and the remaining two are awaiting shipment to San Francisco.

A separate report on the work done under this contract was submitted, dated June 25, 1894.

The Gordon spring return carriage for 12-inch B. L. steel mortar, under contract dated November 23, 1893, was completed and shipped to the Sandy Hook Proving Ground June 29, 1894.

The time for delivery under contract was May 23, 1894, but owing to the delay in receipt of steel castings, extensions to June 15 and July 1, 1894, were granted by the Department.

The following progress has been made on the work under contract dated April 17, 1893, for seven spring return carriages for 12-inch B. L. steel mortars:

The contract as originally made expires October 17, 1894, but owing to the delay in the receipt of mortar from the Department and steel castings from subcontractors the company was granted an extension to November 1, 1894.

Carriage No. 1, completed, except fitting mortar, March 12, 1894.

Carriage No. 2, completed, except fitting mortar, April 24, 1894.

Carriage No. 3, completed, except fitting mortar, May 12, 1894.

The 12-inch B. L. steel mortar was received at the foundry May 24, 1894, but delay in fitting it to these carriages has been caused by cutting threads in trunnions and fitting to Gordon carriage.

Carriage No. 4, upper and lower roller paths and rollers assembled.

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Right and left hand side frames, hydraulic cylinders, piston rods, trunnion carriages, and brackets for elevating gearing ready for assembling.

All parts for training and elevating gearing completed, ready for fitting.

Carriage No. 5, lower roller path completed and training rack fitted in same. Upper roller path machined, but not finished. Rollers completed. Right and left hand side frames, spring cylinder extensions, and connecting brace completed, ready for assembling. Right hydraulic cylinder completed, except plug holes and fitting. Interior diameter of left hydraulic cylinder finished and threads cut for top head and follower. Top heads, bushings, followers, and glands completed for both cylinders. Piston rods completed, except cutting key-way. All machine work done on right trunnion carriage and trunnion bearings for same completed.

All planing done to left trunnion carriage. Right bracket for elevating gearing completed. Left bracket for elevating gearing planed and drilled, but holes not bored for small shafts. All other parts for training and elevating completed.

Carriage No. 6, lower roller path completed, except drilling securing bolt holes and fitting training rack. Training rack completed. Upper roller path machined, holes not drilled. Rollers completed. Right and left hand side frames ready for assembling. Connecting brace completed except drilling holes. Right hydraulic cylinder completed, except plug holes and long oil hole. Right trunnion carriage machined, planed, and trunnion bearings fitted. All parts for training and elevating, except brackets for elevating gearing, completed except fitting.

Carriage No. 7, lower roller path completed, except fitting training rack and drilling securing bolt holes. Training rack completed. Facing upper roller path. Cylinder part of right-hand side frame bored. Left-hand side frame completed except drilling holes. Right hydraulic cylinder finish-bored and threads cut for top head and follower. Finish boring left hydraulic cylinder. All the parts for training and elevating, except brackets for elevating gearing, practically completed except fitting.

A report on the principal operations in the manufacture of these carriages was submitted under date of May 26, 1894.

Tracings of the Gordon spring return mortar carriage accompany this report, inclosed separately. These tracings are numbered 1 to 20, inclusive, also including No. 14½.

W. B. GORDON,
Captain, Ordnance Department, Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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APPENDIX 27.

TEST OF GORDON DISAPPEARING 10-INCH CARRIAGE.

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, September 22, 1893.

SIR: The following report of the test of the Gordon disappearing carriage is respectfully submitted:

This carriage is designed for the 10-inch B. L. rifle, steel, and consists of a heavy bed plate supporting two side frames which carry the movable parts on journals and a pivot plate permanently fastened to the under surface of the bed plate, the whole resting on a heavy cast-iron platform or traverse circle.

The gun is mounted on a top carriage somewhat similar in form to the top part of the old style barbette carriage. Four double cranks are journaled in the side frames, two on each side. The top carriage is mounted on the inner and longer of the crank arms by means of two cross shafts journaled in the top carriage, the ends of the shafts being securely fastened to the crank arms. A counterpoise frame is mounted on the outer and shorter arms. During recoil the gun, top carriage, and counterpoise rotate about their journals, the gun and top carriage describing an arc of about 180 degrees to reach the loading position, while the counterpoise describes an equal and opposite arc, rising while the gun falls. The gun, top carriage, and counterpoise remain parallel to their original positions throughout the motion.

The elevating device is attached to the top carriage, and is independent of any other part of the construction.

The carriage is lifted on an oil pivot for traversing, and a small hydraulic pump is provided for the purpose. Except when raised for traversing, the carriage is in complete contact with its platform.

Between the side frames and secured to the top service of the bed-plate are two hydraulic cylinders 12 inches in diameter. Above and across the front end of these cylinders is an air chamber, separated from the cylinders by check valves opening toward the air chamber; a bypass valve is provided for opening communication from the air chamber to the cylinders around the check valves.

The outer ends of the piston rods are carried by a wheeled truck which runs on rails fastened to the bed plate. From the shafts on which the top carriage is journaled two parallel connecting rods extend to the truck which carries the piston rods. During the recoil these connecting rods close like parallel valves and run the truck and piston rods to the front, thus forcing the liquid from the cylinders through the check valves into the air chamber. Thus the energy of recoil is stored in the air chamber, and it may be utilized in lifting the gun to the firing position. The bypass valve is opened for this purpose. A small air pump is provided to give the required initial pressure in the air chamber.

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For the purpose of maneuvering the carriage by hand a system of gearing is attached to each side of the counterpoise frame, and small platforms are provided for the men required in maneuvering. The gearing turns a pinion which meshes into a circular rack fixed to the side frame. The radius of this rack is equal to the length of one of the arms upon which the counterpoise is mounted.

The rear transom of the counterpoise frame is used as a loading platform. A charge is secured to the latter when the counterpoise is in its lowest position, and this charge is lifted to the loading position by the recoil.

The carriage is very massive, the counterpoise alone weighing upward of 70 tons. The main parts are of cast iron. The cheeks of the top carriage and the cranks and journals are of steel.

The carriage was tested in accordance with the following programme approved by the Chief of Ordnance, viz:

(1) The time required to raise the carriage from the firing to the traversing position to be noted and the number of men necessary.
(2) The facility with which the piece may be traversed and the number of men necessary to be noted.
(3) The time for passing from elevation —5 degrees to that of +20 degrees and the number of men necessary to be noted.
(4) Six rounds to be fired with charges to be determined by the board and the air pressures required for the different charges to be noted.
(5) During the firing of the above rounds the time required for the following operations and the number of men necessary to be noted:
a. For bringing the gun from the loading position to that for charging the air reservoir.
b. For charging the air reservoir with the gun at the highest position at which it would be concealed from the view of the enemy to the pressure required for firing half charge.
c. For charging as above to the pressure required for full charge.
d. For bringing the piece from the charging to the loading position.
e. For bringing the piece from the charging to the firing position.
f. For loading.
g. For raising from the loading to the firing position.
h. For bringing from the recoil to the loading position.
(6) One round with full charge to be fired at each of the elevations —5 degrees, 0 degrees, +10 degrees, and +20 degrees.
(7) Ten rounds with full charges to be fired as rapidly as possible and the time noted.

Preliminary to the official test Capt. Gordon was, by authority of the Chief of Ordnance, allowed to fire 20 rounds to develop the working of the carriage and to make such minor alterations and repairs as might be found necessary:

Of these 20 round numbers 1 to 15, inclusive, were utilized by Capt. Gordon, and during these firings the following changes were found necessary for the convenient working of the carriage.

The inside gear wheels of raising apparatus were broken, and it was necessary to replace them with stronger ones; also the cast-iron lifting arcs were found to be too weak and they were replaced by those of bronze.

The counterpoise was found to be too light, and was made heavier, as follows: Two plates weighing 2,000 pounds each were bolted to the front transom of the counterpoise frame; to the front end of each counterpoise was bolted a plate weighing 2,000 pounds, and to the rear end of each counterpoise a plate weighing 4,000 pounds, and four 12-inch shot, each weighing 800 pounds, were fastened to the under side of the rear transom of the counterpoise frame. This arrangement did not appear, however, to accurately balance the system, and at the point where the cranks attached to the counterweights were horizontal one

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end of the counterweight moved more rapidly than the other, thus making the cranks work against each other, locking the system, and a pig had to be used to move the rear part of the counterweight over the "dead center." To remedy this defect two brackets were fastened to the bed of the carriage, a stud being attached to each bracket. A stud was also fastened to each counterweight, located so that the distance from center to center of the studs on bracket and counterweight when the cranks were horizontal or perpendicular was 2 feet 10 inches. These studs were connected two and two by links, the distance between the holes in the links embracing the studs, being 2 feet 10 inches. This arrangement caused the counterweights to move parallel to themselves in all positions, and prevented the locking of the system, as above described. It should be noted that this "locking" occurred only when the gun was raised by hand power alone. Subsequently, when the air pressure was utilized in assisting the raising of the gun, no "binding" occurred, although the links were removed.

The loading platform, composed of the rear transom of the counterpoise frame, was found to be too near the breech of gun for convenience in loading; the portion of this platform just in rear of the gun was, therefore, cut away, and a new loading platform provided, lowered 2 feet 5 inches and placed 2 feet 4 inches further to the rear. This arrangement allowed ample room for the gun crew to operate when ramming the projectile to its seat in the gun. A platform was also attached to the gun by bands encircling the gun near the breech. This platform was found convenient for the gunner, charged with the duty of closing the breechblock and putting the primer in place ready for firing.

Great difficulty was experienced in the use of the pumps provided with the carriage to raise the latter to its firing position and to secure the pressure in the air chamber necessary to properly control the recoil. Many changes are made in these pumps, but without avail, and they were finally replaced by the pump belonging to the Canét carriage for 12-inch B. L. mortars. This pump was attached to the carriage in rear of the air chamber and over the hydraulic cylinders, and so adjusted that air or liquid could be pumped at pleasure. This pump was found to be a great improvement over those originally provided with the carriage.

The alterations and improvements above described having been made, the official test began on the 13th of July, when the round at 10 degrees elevation was fired in the presence of the Board of Ordnance and Fortification, but owing to the absence of members of the Ordnance Board and press of other work further test was not begun until August 9, on which date the items of the programme were taken at as nearly as possible in their order of sequence, as follows:

(1) The time required to raise the carriage from the firing to the traversing position was on first trial 1 minute 30 seconds. On examination, however, it was found that the cock to the pivot cylinder was not completely open. A new trial was therefore given, the time being thirty seconds; 8 men were working at the pump.

(2) The facility with which the carriage might be traversed could not be ascertained with certainty owing to the fact that the platform on which the carriage was mounted had, during the preliminary firings, settled on one side, so that its upper surface was not horizontal. This caused the pintle to bind in its seat and prevent the traversing of the carriage except through a few degrees. From the limited trial that could be made it is the opinion of the board that the traversing can, under normal conditions, be done with difficulty by 2 men at one

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end of the counterpoise, and with ease by 4 men, 2 at each end of the counterpoise. It would be an advantage, however, to have some means provided for the application of power in traversing.

(3) The time required for passing from elevation of —5 degrees to + 20 degrees was 1 minute 15 seconds, 4 men being required.

(4) Six rounds were fired with charges determined by the board and the air pressures required were noted, as follows:

Number of round.	Weight of charge.	Powder pressure per square inch.	Air pressure before firing.	Air pressure after firing.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1	125	15, 250	47½	77½
2	125	14, 165	85	64
3	125	11, 835	25	54
4	125	19, 500	20	60
5	250	*60, 000	90	245
6	225	58, 500	70	210

* Over.

(5) The times required for the first four operations under No. 5 were not taken, as it was found that the air chamber could be charged with the gun in the loading position, the contrary being the supposition when the programme was prepared. The time required to properly charge the air chamber for a half charge (125 pounds) of powder was found to be 9 minutes, and for a full charge (250 pounds) of power 41 minutes 18 seconds, 10 men working at the pump. The details for each 5 minutes are contained in the record.

f. The gun being in loading position, the time required to load was determined to be 1 minute 43 seconds.

g. The time required to raise the gun from loading position was 2 minutes 7 seconds; the pressure in air chamber at start being 134 pounds and at firing position 47½ pounds.

h. As the gun uniformly recoiled to loading position, this time was not taken.

(6) The round at —5 degrees could not be fired, there being no butt available for the purpose. The rounds at 0, 10, and 20 degrees are numbers 22, 15, and 23 of the record.

(7) The final firings were made for rapidity on September 13. Ten rounds were fired to sea, six being continuous, without delay on account of ships or other obstructions. The actual time required for the ten rounds was determined to be 58 minutes 28 seconds. The details for each round are contained in the record.

In the course of the tests above described 33 rounds have been fired with varying charges as follows:

Number of rounds.	Weight of charge.	Number of rounds.	Weight of charge.
	Pounds.		*Pounds.*
1	100	5	240
8	125	8	245
1	150	11	250
1	175		
1	200	Total, 33	
2	225		

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CONCLUSIONS.

The board, having carefully noted the action of the carriage throughout the test, are of the opinion that it possesses many valuable features which make it superior to any carriage for a similar purpose thus far known to the board. This superiority consists primarily in the fact that the operations of raising and lowering the gun, elevating and traversing, can be performed with comparative ease and quickness without the use of machinery or appliances other than those which may be worked by hand. By the application of machinery these operations could no doubt be performed with still greater certainty and rapidity. The fact, however, that it is possible to perform them by hand, and that under these circumstances 10 rounds can be fired with ease in less than one hour, is considered a remarkable achievement, marking an epoch in the history of the construction in this country of carriages for high-power guns.

The working of the carriage was smooth and regular to a marked degree, confirming the claim of the designer that the system as a whole is one of nonrecoil.

The carriage has disadvantages, some of which can be overcome and others are inherent to the system. It is somewhat heavy and cumbersome, lacking in compactness, and the parts in rear of the gun are so arranged as to prevent easy access to the breech for loading purposes. The necessity for putting the raising apparatus out of gear before firing was a source of considerable trouble, and if the operation were neglected would cause disaster. These objections could be overcome in a new construction.

The use of pumps for raising the system to the traversing position and obtaining the necessary initial air pressure is a disadvantage inherent to the design. These pumps, with their complicated valves and packing are liable to get out of order, and require experts to keep them in good condition. Endless trouble was experienced with the pumps furnished with the carriage. The use of the Canét pump was a great improvement and the tests demonstrated that great care must be taken to select a strong, simple, and effective pump in order to insure the efficient and reliable working of the carriage.

As a result of these tests the board is of the opinion that the Gordon disappearing carriage, mounted on a proper platform, possesses many advantageous and desirable features; and it is thought that with the modifications requisite to overcome the defects noted during the trial it will prove a suitable carriage for issue to the service.

CLIFTON COMLY,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

NOTE.—By authority of the Chief of Ordnance, Capt. Crozier was, at his own request, relieved from duty with the board in rendering the above report.

(3352 C–93)

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing,

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*
1892. A. M. Dec. 21	1	178	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	125	Brown ..1,338 Black ... 7	Cored shot, lot 324.	575, including sand.	244.55	2 00	P, 12,000, in mushroom head. Z, 14,140, in mushroom head. S, 14,100, loose.
1893. P. M. Jan. 27	2	179		100	Brown ..1,070 Black... 7		575, including sand	254.15	2 00	C, 9,100 D, 9,830
Feb. 17	3	180		125	Brown ..1,328 Black... 7		569 6 sand 575	254.75	3 5	A, less than 14,000 X, 14,000
Feb. 21	4	181		150	Brown ..1,607 Black ... 7		570 5 sand 575	254.96	15 00	A, 16,000 X, 16,300

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Arsenal, at Sandy Hook, N. J., December 21, 1892, to April 28, 1893.

test of carriage.]

Recoil.	Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Ft. In.	*Inches.*			Barometer, 30.45; thermometer, 31°; humidity, 79. Gun mounted on Gordon disappearing carriage. Obturating friction primers. Fired to sea.
.....	.....	From right and rear, 16 miles an hour	In recoiling, crosshead of the piston came up against cylinder head, shearing off two small webs on each side. Left main web of crosshead cracked all the way through. Cast iron portion of lower bearings of the front connecting rod broken. One tooth of right lifting arc broken in raising gun. Copper cylinders of 9,000 pounds initial compression and tables of 1890.	When carriage was in firing position the piston rod was 8 feet out of cylinder. Rear clamp of shot tray not of proper diameter. It was removed for repairs. Before test two teeth of left arc for raising gun broken. Air-gauge pressure before firing, 0; air-gauge pressure after firing, 75 pounds. 172 gallons of neutral oil put in cylinders. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
				Barometer, 30.46; thermometer, 34°; humidity, 90. Gun mounted on Gordon disappearing carriage. Obturating friction primers. Fired to sea.
5 2	Not noted.	From rear, 8 miles an hour.	Air pressure before firing, 42 pounds; air pressure after firing, 95 pounds, fell to 86 pounds. The large inside gear wheel of raising apparatus on right side broken while raising. Jack used to assist in raising gun. Copper cylinders of 9,000 pounds initial compression and tables of 1890.	Recoil means travel of piston rod in hydraulic cylinder. Since last firing side castings of truck carrying piston rods replaced, and rubber buffers were lengthened 3 inches. Recoil permitted by carriage is 7 feet 8 inches. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
3 8	Not noted.	From rear, 24 miles an hour.	Air pressure before firing, 50 pounds; air pressure after firing, 85 pounds. Ten men working on handles, 5 on each side. Pressure assisted in raising gun. Men pumped air during raising. Gun did not come down to loading position. Key in left rear crank left out and crank moved over about one-fourth inch. This had to be repaired before next round.	Barometer, 29.25; thermometer, 21°; humidity, 86. Gun mounted on Gordon disappearing carriage. Obturating friction primers. Since last firing the system was weighted as follows:
4 9½	5¾	From right and rear, 8 miles an hour.	Air pressure before firing, 50 pounds; air pressure after firing, 92 pounds. Eight men on handles, 4 on each side. Pressure assisted in raising. Actual time of raising, 3 minutes 15 seconds. The system not being accurately balanced during raising, and at a point where cranks attached to counterweights are horizontal, one end of the counterweight moves more than the other, thus	Two plates, weighing 2,000 pounds each, bolted to front plate attached to counterweights. In front, on each side of counterweights, a plate weighing 2,000 pounds each. In rear, on each side of counterweights, a plate weighing 4,000 pounds each, and four 12-inch shot, weighing 800 pounds each, two on each side of platform in rear.

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet Arsenal,

[Object of firing.

Date.	No. of fire on carriage.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Kind.	Weight.	Number of prisms.	Kind.	Weight.			
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*
1893. Feb. 21	5	182	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	175	Brown..1,877 Black... 7	Cored shot, lot 324.	565 10 sand 575	254.75	15 00	A, 20,200 X, 20,200
Feb. 21	6	183		200	Brown..2,147 Black... 7		569 6 sand 575	254.75	12 00	A, 24,666 X, 24,666
Feb. 21	7	184		225	Brown..2,397 Black.. 7		570 5 sand 575	254.85	10 00	A, 29,477 X, 29,667
Feb. 24	8	185		240	Brown..2,579 Black... 7		566 9 sand 575	254.75	10 00	A, 34,400 X, 34,314

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t Sandy Hook, N. J., December 21, 1892, to April 28, 1893—Continued.

est of carriage.]

Recoil.	Counter recoil.	Wind. strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Ft. In.	*Inches.*			
			making cranks work against each other, locking the system. The front end of counterweights seems to be the heavier, and a pry had to be used to move the rear part of counterweights over this "dead center." This caused a delay of 10 minutes. Gun did not come down to loading position.	The elevating band on 10-inch gun, used for elevating with the pneumatic disappearing carriage, makes a great preponderance to the rear, and men go out on the muzzle to assist in depressing gun for loading.
5 10	4½	From right and rear, 8 miles an hour.	Gun loaded from position of rest after last round by means of gin. Air pressure before firing, 50 pounds; air pressure after firing, 110 pounds, fell to 100 pounds. Eight men on handles, 4 on each side. Pressure assisted in raising. Actual time of raising, 2 minutes 30 seconds. The system locked as it did in previous round. Gun did not come down to loading position. Observed time of flight, 24½ seconds.	Copper cylinders of 14,000 pounds initial compression and tables of 1892. Before firing of the 17th broken gear wheels replaced by new ones and lifting arcs replaced by those of bronze. The counter recoil is probably due to check valves not acting quickly enough.
6 11½	5½	From rear and right, 8 miles an hour.	Gun loaded from position of rest after last round by means of gin. Air pressure before firing, 50 pounds; air pressure after firing, 145 pounds fell to 135 pounds. Eight men on handles, 4 on each side. Pressure assisted in raising. Actual time of raising, 2 minutes 12 seconds. The system locked, as it did in previous two rounds. Gun came nearly to loading position. Observed time of flight, 20½ seconds. Copper cylinders of 18,000 pounds initial compression and tables of 1890.	Barometer, 30.20; thermometer, 15°; humidity, 86. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Capt. F. Heath, Ordnance Department.
7 1½	7½	From rear and right, 8 miles an hour.	Air pressure before firing, 64 pounds; air pressure after firing, 190 pounds, fell to 165 pounds. Eight men on handles, 4 on each side. Pressure assisted in raising. Time of raising, 3 minutes, without stop. Gun came down almost to loading position. Observed time of flight, 18¾ seconds. Copper cylinders of 24,000 pounds initial compression and tables of 1890.	
7 2½	6½	From rear, 23 miles an hour.	Air pressure before firing, 50 pounds; air pressure after firing, 215 pounds, fell to 200 pounds. Nine men on handles, 4 on right and 5 on left side. Time of raising, 7 minutes 15 seconds. Time of flight, 20 seconds. Time fired, 3:10 p. m. Rear clamp of shot tray broken off at hinge. Glass over face of gauge broken by blast. Four bolts holding front elevating worm bracket all sheared off, and bracket moved 2 inches to the front. Bevel gear on rear end of worm shaft came off, but uninjured. Bracket replaced temporarily for next round.	

	Feb. 24.	Feb. 25.
Barometer...	29.80	30.10
Thermometer	36	36
Humidity....	82	82

Gun mounted on Gordon disappearing carriage.
Obturating friction primers.
5 gallons of oil added.

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet Arsenal.

[Object of firing

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
1893.				*Pounds.*			*Pounds.*	*Inches.*	° ′	*Pounds.*
Feb. 24	9	186	Du Pont's brown prismatic V. U., lot 7; density 1.835.	245	Brown.. 2,627 Black... 7	Cored shot, lot 324.	569 6 sand 575	254.75	10 00 11 30 after firing	A. 35,[illegible] X. 35,477
Feb. 25	10	187		250	Brown.. 2,685 Black... 7		570 5 sand 575	254.75	10 00 10 00 after firing	A. 36,400 X. 36,700
Mar. 1	11	188		250	Brown.. 2,664 Black... 7		569 6 sand 575	254.75	10 00 10 00 after firing	A. 36,133 X. 35,100
Mar. 2	12	189		250	Brown.. 2,664 Black... 7		570 5 sand 575	254.75	10 00 10 00 after firing	A. 34,900 X. 34,350
Apr. 28	13	190		125	Brown.. 1,328 Black... 7		570 5 sand 575	254.40	2 00	.....

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t Sandy Hook, N. J., December 21, 1892, to April 28, 1893—Continued.

ist of carriage.]

Recoil.	Counter recoil.	Wind strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Ft. In.	*Inches.*			
6 10½	7½	From rear, 23 miles an hour.	Air pressure before firing, 90 pounds; air pressure after firing 250 pounds, fell to 210. Nine men on handles, 4 on right and 5 on left side. Time of raising, 6 minutes. Time of flight, 19½ seconds. Time of firing, 5:15 p. m. Elevating worm bracket slipped forward.	Fired to sea. Copper cylinders of 32,000 pounds initial compression and tables of 1892. Front elevating band slipped forward and had to be driven back after each round. Before firing of Feb. 25 four new bolts put in elevating worm bracket and a piece of iron bolted down to carriage in front of bracket to prevent it slipping forward.
6 11	6½	From rear, 14 miles an hour.	Air pressure before firing 90 pounds; air pressure after firing, 275 pounds, fell to 250 pounds. Seven men on handles, 4 on right and 3 on left side. Time of raising, 10 minutes 30 seconds. Time of flight, 20 seconds. Time of firing, 1:45 p. m.	
7 3½	4½	From right and rear, 22 miles an hour.	Air pressure before firing, 80 pounds; air pressure after firing, 270 pounds, fell to 250 pounds. Eight men on handles, 4 on each side. Time of raising not taken. Time of flight, 20 seconds. Front clamp of shot tray broken off near hinge.	Four springs under the connecting rod bearings of the top carriage removed. Fired to sea. Copper cylinders of 32,000 pounds initial compression and tables of 1892. Firing conducted by Lieut. L. St. J. Greble, Second Artillery, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department. Barometer, 30.22; thermometer, 52°; humidity, 71.
7 4	5	From right, 26 miles an hour.	Air pressure before firing, 80 pounds; air pressure after firing, 255 pounds, fell to 245 pounds. Eight men on handles, 4 on each side. Time of raising, 3 minutes. Time of flight, 19½ seconds.	Gun mounted on Gordon disappearing carriage. Obturating friction primers. Fired to sea. 20 gallons of neutral oil added to cylinders before firing. Before this firing, handles on wheel of oil pump lengthened. Enlarged pistons from 1 inch to 1⅛ inches. Put in new valves three-fourths inch in diameter in place of five-eighths inch valves. Two links to brackets on frame made and two studs on counterweights made. Cut out rear platform and put in new one, and lowered it 2 feet 5 inches, and extended it 2 feet 4 inches to the rear. A telltale for cylinder, to see how much oil there is in cylinder, made and fitted.
Not taken.	Not taken.	.....	Air pressure before firing, 33 pounds, equals one point of hydraulic gauge. Glass face over gauge broken by blast. In recoiling gun came down nearly to loading position and then rose up part way and remained.	

	Mar. 1.	Mar. 2.
Barometer....	30.06	30.07
Thermometer.	38	38
Humidity.....	75	75

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing.

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.
				Lbs.			*Lbs.*	*Inches.*	° ′
P. M. May 26	14	191	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	250	.....	Cored shot, lot 324.	569 6 sand 575	254.375	16 45

[Object of firing, exhibition before the

P. M. July 13	15	192	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	250	*2,683 †7	Cored shot, lot 324.	570 5 sand 575	254.25	10 0

[Object of firing, test of Gordon

P. M. July 14	16	193	Du Pont's brown prismatic U.U., lot 7; density, 1.835.	125	*1,340 †7	Cored shot, lot 324.	569 6 sand 575	254.125	10

*Brown. †Black.

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[rsenal, at Sandy Hook, N. J., May 26 to September 13, 1893.

est of carriage.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	General remarks.
Pounds.	*Ft. In.*	*Ft. In.*		
P, 37,800 4, 36,650			Air pressure before firing, 80 pounds, and dropped to 65 pounds while waiting for ships to get out of range (this in about 30 minutes); pressure pumped up again to 80 pounds just before firing. Air pressure after firing not recorded; indicator on face of gauge blown off. The hydraulic pump was removed before this firing. The carriage was raised from its platform by two 2-inch planks in front and two 2-inch planks in rear of the pivot, these planks being placed between the bed plate and the platform.	Gun mounted on Gordon disappearing carriage. Obturating friction primers. 10 gallons of oil added. Fired to sea. Before firing, the piston rod was 8 feet out of cylinder; after firing, the piston rod was 3 feet 9½ inches out of cylinder. The string on piston rod was 1½ inches from its end, so that the recoil measured on the piston rod 7 feet 10½ inches; the counter recoil was 3 feet 8 inches. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, U. S. A., in the presence of the Ordnance Board. Present: Capt. F. Heath, Capt. W. Crozier.

Board of Ordnance and Fortification.]

U, 39,500 N, 39,400	7	9½	2	2½	Air pressure before firing, 100 pounds; air pressure after firing, 225 pounds. Gun came to buffers, raised slightly, and there remained. The gun was again loaded and raised to firing position. Air pressure, 65 pounds. As the pump could not be made to work, the charge of powder was withdrawn and the piece secured. Copper cylinders of 32,000 pounds initial compression and tables of 1892. The lips of both cups turned off and seat made for split rings. Two split rings made and used on pad and one split ring on spindle, these modifications being similar to those shown by drawing for obturator of 12-inch rifle (steel), dated May 6, 1893.	Gun mounted on Gordon disappearing carriage. Obturating friction primers. Fired to sea. Before firing, 105 gallons of neutral oil put in cylinders, filling them. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, in the presence of the Board of Ordnance and Fortification. Present: Maj. Gen. J. M. Schofield, Gen. H. L. Abbot, Col. H. W. Closson, Maj. C. Comly, Capt. C. C. Morrison, Mr. B. M. Cutcheon.

disappearing carriage.]

N, 11,670 U, 12,600	4	½		1	Before this round the tin packing in air pump was removed and the air pump repaired. It took 10 men working three hours to get the carriage ready to fire after the pump was repaired. About 60 pounds was all the pressure that could be obtained. Copper cylinders of 9,000 pounds initial compression and tables of 1890.	Gun mounted on Gordon disappearing carriage. Barometer, 30.12; thermometer, 76°; humidity, 66. Obturating friction primers. Before this firing, 10 gallons of water and 20 gallons of oil added to cylinders to bring oil over check valves. Fired to sea. Firing conducted by Lieut. E. St. J. Greble, Second Artillery, in the presence of the Ordnance Board. Present: Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.
P. M. July 14	....			*Lbs.*			*Lbs.*	*Inches.*	°
Aug. 10	17	194	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	125	*1,320 †7	Cored shot, lot 324.	570 5 sand 575	254.25	10 00

* Brown. † Black.

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Arsenal, at Sandy Hook, N. J., May 26 to September 15, 1896—Continued.

test of carriage.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.
Pounds.	*Ft. In.*	*Ft. In.*	
			The gun was in the firing position. The Canét pump had been rigged to pump both air and liquid. It was on the left side of the carriage and just in rear of platform on counterweights. The connections of pump were so made that the air had to be pumped through liquid and check valves of air cylinder. A detachment of a noncommissioned officer and 12 men was used. The outer end of pinion shaft on left side of carriage was broken. The gun was first lowered to the loading position. Time, 6 minutes 30 seconds; 5 men on raising gear on each side. Eight men then manned the pump, which was rigged to pump liquid. The carriage was raised to the traversing position. Time, 1 minute 30 seconds. The cock to pivot cylinder was not all the way open, so another trial was given; 300 pounds was kept on the pivot to hold it well up against carriage. The pressure was shut off from gauge. When the pump was started (8 men working) the cocks to pivot and pump were opened wide. The pressure was 800 pounds; time to raise carriage to traversing position, 30 seconds. The carriage was then traversed. It was then raised one-eighth inch higher; 12 strokes of the pump were necessary; time, 9½ seconds. Two men were put on each end of the carriage. These 4 easily traversed it. Then 2 men pushing at the end of the loading platform traversed it with difficulty. The gun was then elevated from 5° depression to 20° elevation. Two men on each elevating wheel (4 men on muzzle), the noncommissioned officer on small loading platform on gun. Time, 1 minute 15 seconds. The gun was depressed from 20° elevation to 5° depression. Noncommissioned officer off platform, other men same as before. Time, 1 minute 56 seconds. The pump was rigged to pump air. 10 men pumping in reliefs of 2 up to 120 pounds; from 130 to 150 pounds in reliefs of 4, one-half minute shifts. When there is no air pressure in cylinder the gauge reads 5 pounds. The gauge on pump shows pressure as follows. Pumping began at 10:28 a. m.

Pressure.	Hours.	Minutes.	Seconds.	Remarks.
35 pounds at.....	10	32	50	
40 pounds at.....	10	34	.....	
45 pounds at.....	10	35	.....	Strokes varied from 120 to 160 half strokes per minute.
50 pounds at.....	10	36	.....	
55 pounds at.....	10	37	.....	
60 pounds at.....	10	38	.....	
65 pounds at.....	10	39	.....	140 half strokes per minute.
70 pounds at.....	10	40	.....	
75 pounds at.....	10	41	.....	
80 pounds at.....	10	42	20	
85 pounds at.....	10	43	22	165 half strokes per minute.
90 pounds at.....	10	44	20	
95 pounds at.....	10	45	30	
100 pounds at.....	10	46	30	158 half strokes per minute.
105 pounds at.....	10	47	35	
110 pounds at.....	10	48	30	148 half strokes per minute.
115 pounds at.....	10	49	30	
120 pounds at.....	10	+51	.....	
125 pounds at.....	10	+52	.....	
130 pounds at.....	10	+53	.....	
135 pounds at.....	10	54	30	
140 pounds at.....	10	55	20	
145 pounds at.....	10	56	38	
150 pounds at.....	10	57	48	
Total time.....		29	48	

N, 15,500 V. 15,000	4	¼	0	2¾

The detachment same in number as on the ninth. The gun in loading position. Time to load, 1 minute 43 seconds. One-half charge (125 pounds) used. The gun was then raised to firing position, 5 men on each side of raising handles. Time, 2 minutes 7 seconds. Air pressure at start, 134 pounds; at firing position, 47½ pounds. The gun was fired at 10° elevation. On firing, the by-pass valve and the cocks to cylinder head were shut. Shortly after the shot struck the water these two cocks were open and the gauge read 77½ pounds. The cylinders before firing were filled to the proper height with oil, about 4 gallons being added. Recoil, 4 feet ¼ inch; counter recoil, 2¾ inches.

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Record of firing with 10-inch B. L. rifle (steel) No. 1, Watervliet

(Object of firing.

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.
				Lbs.			*Lbs.*	*Inches.*	° ′
P. M. Aug. 10	18	195	Du Pont's brown prismatic V. U. lot 9; density, 1.850.	125	*1,320 †7	Cored shot, lot 324.	569 6 sand 575	254.25	10 00
Aug. 10	19	196	Du Pont's brown prismatic V. U. lot 9; density, 1.850.	125	*1,320 †7	Cored shot, lot 324.	569 6 sand 575	254.25	10 00
Aug. 15	20	197	Du Pont's brown prismatic V.U., lot 9; density, 1.850.	125	*1,320 †7	Cored shot, lot 324.	570 5 sand 575	254.25	9 45
Aug. 16	21	198	Du Pont's brown prismatic V.U., lot 9; density, 1.850.	250	*2,646 †7	Cored shot, lot 324.	569 6 sand 575	254.25	9 30

*Brown. †Black.

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Arsenal, at Sandy Hook, N. J., May 26 to September 13, 1893—Continued

test of carriage.]

Pressure per square inch of bore.	Recoil.	Counter recoil	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.
Pounds.	*Ft. In.*	*Ft. In.*	
N, 14,300 V 14,000	5 7½	0 1½	The gun was again loaded with half charge (125 pounds), a gin being used to load shot, and fired at 10° elevation. Pressure was reduced to 35 pounds by gauge. It was 64 pounds after firing. Recoil, 5 feet ¾ inch; counter recoil, 2 inches.
N, 12,670 V, 11,000	5 7½	0 1½	The gun was again loaded with half charge (125 pounds), a gin being used to load shot, and fired at 10° elevation. Air pressure before firing, 25 pounds by gauge; after firing, 54 pounds. Recoil, 5 feet 7½ inches; counter recoil, 1½ inches. The pressure was 54 pounds, and left over night. The pressure the next morning was 49 pounds.
			Before this fire the pump was moved, mounted on skids laid across the recoil cylinders just in rear of the air cylinder. The connections were changed so that the pump would pump air over the check valves in the air cylinder. The gun was fired at 9:45 a. m., with half charge (125 pounds). Pressure before firing, 20 pounds; after firing, 60 pounds. Recoil, 6 feet; counter recoil, ¾ inch. The pressure was pumped to 150 pounds. No time taken. Ten men, working in reliefs of 2 minutes 15 seconds shifts, pumped from 150 to 180 pounds. Pumping began at 10:26:30 a. m.

Pressure.	Hours.	Minutes.	Seconds.	Pressure.	Hours.	Minutes.	Seconds.
155 pounds at	10	27	30	175 pounds at	10	32	....
160 pounds at	10	28	30	180 pounds at	10	33	....
165 pounds at	10	30	....				
170 pounds at	10	31	....	Total time	....	6	30

V, 19,450 X, 19,650	6 90	0 ¾	The pressure was 180 pounds, and left so over night. Aug. 16, at 9:30 a. m., the piston rod had moved 3 inches to the rear. The air pressure read 159 pounds; the pressure was pumped back to 182 pounds. No time taken.

[Time from 182 to 250 pounds.]

Pressure.	Hours.	Minutes.	Seconds.	Pressure	Hours.	Minutes.	Seconds.
182 pounds at	9	38	15	230 pounds at	9	47	....
190 pounds at	9	39	30	240 pounds at	9	48	45
200 pounds at	9	41	15	250 pounds at	9	50	30
210 pounds at	9	43	15				
220 pounds at	9	45	....	For 68 pounds	....	12	15

Over 60,000	6 7½	4 ¾	Ten men, working in 5 reliefs of 2 at a time for 15 seconds each. Strokes vary from about 100 to 160 half strokes per minute. The gun was then loaded with full charge (250 pounds), and raised in 1 minute 52 seconds, this from the position the gun was in at 9:30 a. m. to the firing position. Air pressure started at 250 pounds, and was at 102 pounds when gun was in firing position. Air let off and pressure reduced to 90 pounds by gauge, after firing. Pressure, 245 pounds. Recoil, 6 feet 7½ inches. Counter recoil, 4¾ inches. Steadying link on left side broken off. Pump moved 4½ inches to rear by jar from discharge. Shot truck and shot fell off rails on loading platform. Pressure, over 60,000 pounds. The pump was moved back to its original position and fastened to beams of platform by 4 lag screws. The beams of platform were lashed to cylinders.

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing.

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.
				Lbs.			*Lbs.*	*Inches.*	
Aug. 16	22	199	Du Pont's brown prismatic V. U., lot 9: density, 1.850.	225	*2,390 †7	Cored shot, lot 324.	570 5 sand 575	254.25	0 00
Sept. 12	23	200	Du Pont's brown prismatic V. U., lot 7. density, 1.835.	250	*2,687 †7	Cored shot, lot 324.	570 5 sand 575	254.25	20 00

[Object of firing, test of

Sept. 13	24	201	Du Pont's brown prismatic V. U., lot 2; density, 1.840.	250	*2,727 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	25	202	Du Pont's brown prismatic V. U., lot 7: density, 1.835	250	*2,684 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00

*Brown. †Black.

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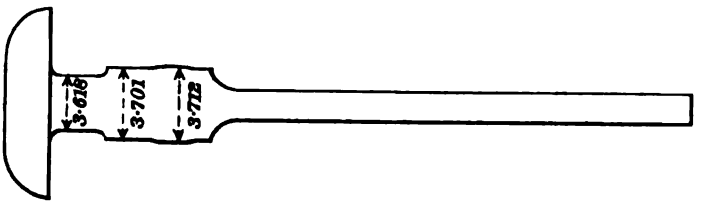
...senal, at Sandy Hook, N. J., May 26 to September 13, 1893—Continued.

...t of carriage.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.
Pounds.	*Ft. In.*	*Ft. In.*	
V, 57,100 X, 59,900	6 9	0 3½	The gun was again loaded with 225 pounds of powder, and fired at 0°. Air pressure before firing, 70 pounds; after firing, 210 pounds. Pressure, about 58,000 pounds. The spindle was broken off at first thread, the two locking nuts and antifriction rings blown to the rear and fell about 15 feet in rear of carriage.



D, 39,600 M, 37,000	6 9½	0 1½	Air pressure before firing, 90 pounds; air pressure after firing, 215 pounds. Time of flight, 30⅔ seconds.

...carriage for rapidity.]

Barometer, 30.43; thermometer, 71°; humidity, 72.

[Time consumed in firing 10 rounds, 1 noncommissioned officer and 15 men being employed. The detachment was in the loading position, the breechblock open, but loading tray in firing position.]

				Hours.	Minutes.	Seconds.	Actual time for various operations.
			FIRST ROUND.				
			Started to load at	9	49	15	
			Shot rammed at	9	49	45	30
			Powder in	9	52		2 15
			Gun at firing position	9	53	40	1 40
V, 47,200 D, 46,200	6 6¼	0 2½	Gun ready to fire	9	55	5	1 25
			Time was taken at 9° 55′ 5″, to enable ships to get out of the field of fire, 1 minute from 9° 55′ 5″ to 9° 56′ 5″				
			Gun fired at	9	56	5	
			Time consumed in firing first round		5	50	
			SECOND ROUND				
			Started to load at	10	25	25	
			Gun in firing position and time taken	10	29		3 35
			Could not fire on account of ships in the way				
			Gun fired at	10	47	3	
	6 6½	0 1½	Detachment in position to load	10	47	43	40
			Time consumed in firing second round		4	15	
			Flange on end of pinion shaft on left side broken, and pinion had to be engaged each time by using hand spike for remaining rounds.				

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervliet

[Object of firing.

Date.	No. of fire on carriage.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.
			Kind.	Weight.	Number of prisms.	Kind.	Weight.		
				Lbs.			*Lbs.*	*Inches.*	°
Sept. 13	26	203	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	250	*2, 685 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	27	204	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	250	*2, 685 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	28	205	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	245	*2, 630 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	29	206	Du Pont's brown prismatic V. U., lot 7; density, 1.835.	245	*2, 628 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	30	207	Du Pont's brown prismatic V. U., lot 2; density, 1.840.	240	*2, 614 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	31	208	Du Pont's brown prismatic V. U., lot 2; density, 1.840.	240	*2, 614 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00

* Brown. † Black.

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rsenal, at Sandy Hook, N. J., May 26 to September 13, 1893—Continued.

st of carriage for rapidity.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	Hours.	Minutes.	Seconds.	Actual time for various operations.
Pounds.	*Ft. In.*	*Ft. In.*					
			THIRD ROUND.				
			Started to load at	11	2	42	
			Gun ready to fire at	11	9	3	6 21
D. 43,000 C. 35,000	6	5½ 0 1½	Time taken at 11° 9′ 3″, to enable ships to get out of the field of fire				
			Gun fired at	11	14	30	
			Time consumed in firing third round		6	21	
			FOURTH ROUND.				
			Third round fired at	11	14	30	
			Detachment in loading position for fourth round	11	16	58	2 28
			Time taken at 11° 16′ 58″, to enable pressure plugs to be removed				
			Resumed loading	11	33	12	
	6	6 0 1½	Gun in firing position	11	36	7	2 55
			Ready at	11	36	48	41
			Time taken at 11° 36′ 48″, to enable ships to get out of line of fire				
			Gun fired at	11	44	23	
			Time consumed in firing fourth round		6	04	
			FIFTH ROUND.				
			Fourth round fired at	11	44	23	
			Detachment in loading position for fifth round	11	45	17	54
	6	5 0 2	Gun in firing position	11	48	42	3 25
			Gun fired at	11	48	53	11
			Time consumed in firing fifth round		4	30	
			SIXTH ROUND.				
			Fifth round fired at	11	48	53	
			Detachment in loading position for sixth round	11	49	33	40
	6	4 0 1½	Gun in firing position	11	54	20	4 47
			Gun fired at	11	54	30	10
			Time consumed in firing sixth round		5	37	
			SEVENTH ROUND.				
			Sixth round fired at	11	54	30	
			Projectile rammed	11	56	2	
			Powder in	11	56	40	
	6	2½ 0 1½	Block closed	11	57	10	
			Primer in	11	57	23	
			Gun in firing position	11	58	52	
			Fired at	11	59	13	
			Time consumed in firing seventh round		4	43	
			EIGHTH ROUND.				
			Seventh round fired at	11	59	13	
			Breechblock opened	12	0	2	
			Shot in	12	0	42	
			Powder in	12	1	22	
	6	2½ 0 1	Block closed	12	1	41	
			Primer in	12	1	52	
			Ready for firing	12	6	40	
			Fired at	12	7	1	
			Time consumed in firing eighth round		7	48	

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Record of firing with 10-inch B. L. rifle (steel), No. 1, Watervl

[Object of firing

Date.	No. of fire on carriage.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.
			Kind.	Weight.	Number of prisms.	Kind.	Weight.		
				Lbs.			*Lbs.*	*Inches.*	° ′
Sept. 13	32	209	Du Pont's brown prismatic V. U., lot 2; density, 1.840.	240	*2,616 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00
Sept. 13	33	210	Du Pont's brown prismatic V. U., lot 2; density, 1.840.	240	*2,615 †7	Cored shot, lot 324, weighted up with sand.	575	.....	4 00

* Brown. † Black.

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Arsenal, at Sandy Hook, N. J., May 26 to September 15, 1893—Continued.

test of carriage for rapidity.]

Pressure per square inch of bore.	Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc., and metrological data.	Hours.	Minutes.	Seconds.	Actual time for various operations.
Pounds.	*Ft. In.*	*Ft. In.*					
			NINTH ROUND.				
			Eighth round fired at	12	7	1	.....
			Breechblock opened	12	8	17	.....
			Shot in	12	8	30	.....
			Powder in	12	9	8	.....
.....	6 2½	0 ½	Block closed	12	9	20	.....
			Primer in	12	9	29	.....
			Gun in firing position	12	14	19	.....
			Fired at	12	14	30	.....
			Time consumed in firing ninth round	....	7	29	.....
			TENTH ROUND.				
			Air pressure before firing, 80 pounds. Before this firing a new mushroom head was fitted to breechblock, one which was taken from 10-inch B. L. R., No. 6. After firing, the front band on gun holding elevating arc had moved forward three-eighths of an inch. The left front pin bearing of the counterweight has moved up out of its seat five-sixteenths of an inch. Rear hand rail collar on gun moved to the front one-fourth of an inch.				
.....	6 2½	0 1	Ninth round fired at	12	14	30	.....
			Breech block opened	12	15	17	.....
			Shot in	12	15	51	.....
			Powder in	12	16	29	.....
			Block closed	12	16	52	.....
			Primer in	12	17	3	.....
			Gun in firing position	12	20	21	.....
			Time consumed in firing tenth round	....	5	51	.....
			Actual time consumed in firing ten rounds	....	58	28	.....

Firing conducted by Lieut. E. St. J. Greble, Second Artillery, U. S. A., in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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APPENDIX 28.

TEST OF BUFFINGTON-CROZIER 8-INCH CARRIAGE.

(2 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, December 29, 1893.

SIR: The following report of the test of the 8-inch Buffington-Crozier disappearing carriage is respectfully submitted:

DESCRIPTION.

The carriage consists of the following principal parts, viz: The rotating arms, the top carriage, the cheek plates or chassis, the elevating gear, the upper front roller path, the live rollers, the lower front roller path, the bracket for the rear traverse wheels, the rear traverse wheels, the rear traverse circles, the traversing gear, the loading crane.

The gun rests by its trunnions on the upper ends of the rotating arms in bearings bushed with bronze. The rotating arms are made of cast steel. They are pivoted near their middle points upon an axle of forged steel, and are connected beneath the gun by a ½-inch plate transom.

The axle rests in bearings bushed with bronze, in the top carriage, which is formed with the two hydraulic cylinders in two pieces of cast steel bolted together. In each cylinder are two throttling bars of steel which pass through notches in the pistons. They serve to regulate the size of the orifices for the flow of the liquid past the pistons, being of variable cross section. The hydraulic cylinders are connected by a pipe at their forward ends to equalize the pressure in them during recoil.

The piston rods, with the pistons formed on them, are made of forged steel and are fastened by means of nuts to projections on the chassis. They are pierced throughout their length with holes 1 inch in diameter to permit the passage into the cylinders of liquid which comes to their forward ends through copper pipes, from a reservoir placed on the chassis. These pipes at their point of junction are provided with a check valve, which prevents the return of the liquid from the cylinder, and with a by-pass valve, which when opened permits the return flow of the liquid past the check valve. The object of this arrangement is to retain the gun in a position of recoil too high for the pawls mentioned below to catch, and so control its return to the firing position.

The top carriage runs upon rollers of forged steel, which are placed in recesses in the cheek plates. The axles of the rollers are of forged steel and the rollers are bushed with bronze where the axles pass through them.

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The cheek plates are made of cast steel, and are united by a transom, also of cast steel, and by the bracket for the rear traverse wheels. They are bolted at their forward ends to the upper front-roller path. They have bolted to them guides for the elevating racks.

The elevating rods are of forged steel. The journal bearings at their upper and lower ends are bushed with bronze. The lower ends of the rods are attached to elevating racks of forged steel. The elevating hand wheels are of wrought iron. They are mounted on a through shaft, upon which are pinions of bronze gearing into spur wheels of cast steel, on the shaft with which are pinions of bronze gearing into the elevating racks.

The upper and lower front roller paths are of cast steel. Their inner parts form the pivot or pintle, which has a spiral groove cut in one of the surfaces to facilitate lubrication. The lower one is fastened to the platform with eighteen 1¾-inch holding-down bolts.

The conical rollers are of forged steel. The counterweight is of cast iron and weighs 37,000 pounds. It is suspended by two rods from a shaft joining the lower ends of the rotating arms. The shaft from which the counterweight hangs is of forged steel. It passes through the lower ends of the rotating arms and into two sliding pieces forming a crosshead, the holes in the rotating arms being bushed with bronze. It is pinned to the pieces with which it forms the crosshead. The crosshead pieces are of cast steel and are lined on their principal bearing surfaces with bronze strips. They are given additional support when in their lowest position by bronze fitting pieces bolted to ribs of the chassis. The crosshead guides are formed on the inner sides of the chassis. A vertical ratchet is formed on one face of each crosshead piece to be caught by a pawl on the cheek plate and hold up the counterpoise. This pawl is mounted upon a short crank actuated by a long lever at the side of the carriage, which arrangement is used for lowering the piece should the recoil not be quite sufficient.

The rear traverse wheels and their brackets are of cast steel. The axis of the wheels rest in roller bearings. The teeth of all gears and racks in the elevating and traversing gear are machine finished.

The traversing chain lies around the rear traverse circle and is fastened to the parapet. It is provided with an arrangement for taking up the slack. The rear traverse circle is of cast steel. It is cast in segments and fastened to the platform by 1½-inch holding-down bolts.

The action of the carriage is as follows: Upon firing the piece the central pivot of the rotating beam moves horizontally to the rear, carrying the top carriage with it; the lower end moves vertically upward, being constrained by the crosshead guides, the gun moves downward and to the rear in the arc of an ellipse. The energy of recoil is absorbed partly by raising the counterweight and partly by the resistance of the hydraulic cylinders. After loading, the pawls are tripped and the greater moment of the counterpoise enables it to raise the piece into battery. The latter can be stopped and held in any position by closing the by-pass valve.

The reservoir supplies liquid to fill the vacuum which would otherwise be left in the hydraulic cylinders by the withdrawal of the piston rods upon recoil, thus preventing air from leaking in.

The piece is hauled down into the loading position by hand, for drill or cleaning, by blocks and falls attached to the upper ends of the rotating arms and to lugs on the cheek plates.

Three fulcrum pins are inserted in each chassis near the forward end of the top carriage to serve as points of support for pinching levers held

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vertically and engaging in ratchets bolted to the under sides of the top carriage clips, for heaving the top carriage forward in case it should not return to the firing position.

A spring prevents the loading crane from swinging to a position under the breech of the gun where it might be struck by the latter upon recoil.

For hauling the gun down by hand without firing, two triple blocks are used and a luff tackle of two double blocks, 4,000 pounds of lead pigs being removed from the counterweight.

The following programme was adopted for the test:

(1) As many rounds as may be necessary to be fired with varying charges and at any time during the test, for making adjustments, etc.
(2) The time for traversing, with the gun up, through as many degrees as are permitted by the proof platform and the number of men necessary to be noted.
(3) The time for passing from elevation —5 degrees to +15 degrees and the reverse, with the gun up, and the number of men necessary to be noted.
(4) The time for bringing from the firing to the loading position by hand and the number of men necessary to be noted.
(5) The time for traversing, etc., as in No. 2, with the gun down, to be noted.
(6) The time for elevating, etc., as in No. 3, with the gun down, to be noted.
(7) The time for loading and the number of men necessary to be noted.
(8) The time for raising from the loading to the firing position and the number of men necessary to be noted.
(9) Five rounds to be fired with charges to be determined by the board, during which the following points will be noted:
(*a*) The recoil of the top carriage for each charge.
(*b*) The counter recoil of the top carriage, if any, for each charge.
(*c*) The distance of the trunnions from the loading position for each charge.
(*d*) The time required for bringing from the recoil to the loading position and the number of men necessary for each charge.
(10) One round with full charge to be fired at each of the elevations —5 degrees, 0 degrees, +5 degrees, +10 degrees, and +15 degrees.
(11) Ten rounds with full charges to be fired as rapidly as possible and the time noted.

The carriage was assembled, and 8-inch B. L. rifle, Watervliet Arsenal No. 1, was mounted upon it.

One round was fired with each of the charges 25, 50, 75, 85, 100, 115, and 123 pounds. As the gun with the last mentioned charge did not recoil far enough for pawls to catch and hold it in the loading position, the counterweight was in the following 7 rounds successively reduced, by the removal of lead pigs, to the following: 36,700, 36,200, 35,500, 35,000, 34,500, 34,000, 33,000 pounds, each round being with the full charge of 125 pounds. As the recoil was still insufficient for the pawls to catch, the throttling bars were then removed and their curves deepened so as to increase the areas of the orifices for the flow of the liquid by 10 per cent, and the counterweight increased to its original weight of 37,000 pounds.

Firing was recommenced with the charge of 75 pounds, with which the pawls still failed to catch, but at the next round, which was with full charge, they caught upon the ninth tooth of their racks, leaving the gun 11½ inches from the recoil buffers, there being 17 teeth of 1½-inch pitch in each rack. In the two following rounds the counterweight was successively reduced to 36,500 and 36,000 pounds, the pawls in each case catching on the eleventh tooth of the racks. Two rounds were then fired with charges, respectively, of 100 and 90 pounds to ascertain the effect of reduced charges. With 100 pounds the pawls caught on the sixth tooth, and with 90 pounds on the third tooth, of the racks.

The pistons were then removed from the hydraulic cylinders and the bottom surfaces of the slots for the throttling bars were beveled in each direction 0.015 inch, so as to facilitate the flow of the liquid, and the counterweight increased again to 37,000 pounds. A round was then

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fired with 100-pound charge, when the pawls caught on the sixth tooth of the racks; the charge was increased to 125 pounds, when they caught on the tenth tooth. The counterweight was then reduced successively to 36,500 and 36,000 pounds, the pawls catching on the twelfth and thirteenth tooth, respectively.

The pistons were then again removed, the slots deepened 0.015 inch, and their bottom surfaces beveled 0.02 inch. The pawls then with 100 pounds charge and 37,000 pounds counterweight caught on the sixth tooth of the racks; with full charge and 36,500 pounds counterweight they caught on the fourteenth tooth.

The pistons were again removed, the slots deepened 0.02 inch and beveled 0.02 inch, when with 100 pounds charge and 37,000 pounds counterweight the pawls caught on the sixth tooth of the racks, and with full charge, with 36,700 pounds counterweight, in the sixteenth tooth, which was satisfactory, and no further alterations for the purpose of increasing recoil was made.

To ascertain the effects of reduced charges, a round was then fired with 80 pounds of powder and 37,000 pounds counterweight. The pawls caught on the second tooth of the racks. The charge was then reduced to 65 pounds and the counterweight to 34,000 pounds, when the pawls caught on the first tooth of the rack, on the right-hand side only. As a reduction of the counterweight below 33,000 pounds will not leave it with sufficient moment to raise the piece far enough for the pinching levers, for heaving it forward into the firing position, to be engaged, no further reduction of charge and counterweight is permissible.

The adjustment being complete, one round was then fired with full charge at each of the elevations 14°, 5°, 0°, and — 5°, all the preceding firing being at elevation about 11°. At 14° the pawls caught on the sixteenth tooth of the racks, at the other elevation on the seventeenth or last tooth, the rotating arms gently touching the recoil buffers and the piece running clear up into the firing position, upon tripping the pawls. Before the round at 0° 200 pounds were added to the counterweight, and before the round at —5° 100 pounds additional, making it 37,300 pounds without producing any apparent effect.

During the course of the preceding fire the following observations were made:

	′	″
Time of traversing through an angle of 54°, with the gun in the firing position and two men at the cranks	1	13¼
Time for passing from elevation —5° to +14° with the gun in the firing position and two men on the elevating wheels	0	13¼
From +14° to —5° with four men	0	20
Time of bringing from the firing to the loading position by hand with 12 men, 12 minutes 29 seconds, and for replacing pigs removed from the counterweight for this operation 6 minutes 46 seconds, making a total of	19	15
Time for traversing through an angle of 54° with the gun in the loading position and four men at the cranks	1	14¼
Time for passing from elevation —5° to +14° with the gun in the loading position and two men at the elevating wheels	0	8¼
From +14° to —5° with four men	0	18
Time for loading (from rapidity test) about	0	68
Time for raising from the loading to the firing position with two men to trip the pawls	0	4

The difference in time for elevating and depressing is due to the weight of the elevating rods.

As the piece could be loaded at any position at which the pawls would catch, no time was required for bringing from the recoil to the loading position. The by-pass valve for retaining the piece in a position of recoil was not used, as it was unnecessary and it was considered safer to have it inoperative by fastening it permanently open. If the

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pawls should be tripped with this valve inadvertently closed, the pressure produced would burst the pipe connections.

From the beginning of the test no breakage or other accident of any description occurred, but in addition to those affecting the throttling orifices, previously noted, the following slight changes were made for the purpose of increasing the facility of maneuvering.

(1) The handles at the sides of the carriage for raising the counterweight were lengthened and bent slightly outward.
(2) Forty pigs of lead of about 100 pounds each, with iron ring handles attached, were substituted for an equal weight of the cast-iron counterweight.
(3) A thick rubber ring was put at the forward end of each piston rod as a counter recoil buffer.
(4) A brass pointer was fastened so as to indicate the elevation of the piece upon the left hand exterior gear of the elevating mechanism.
(5) Wire screens were put in the curved pipes, screwed into the air holes of the reservoir for the purpose of checking the projection of oil from these pipes when the piece returned to the firing position. They were only partially efficient.
(6) The loading crane was shortened 9 inches to bring the projectile nearer the breech of the gun.
(7) The lugs on the inner sides of the chassis were lowered about 2 feet for convenience of attaching the hauling-down blocks.
(8) A heavy screw eye was added as a fulcrum for tripping each pawl, nearer the pawl and lower down than the one provided with the carriage.
(9) An additional air hole was drilled at the front end of each hydraulic cylinder to prevent the formation of an air cushion.
(10) A 2-inch rope was substituted for the loading chain and guides provided to prevent its slipping off the pulleys.
For convenience in hauling the gun down while making adjustments a steam capstan was substituted for the luff tackle.

As a final test the gun was fired ten rounds for rapidity, two rounds being first fired for the purpose of thoroughly liquifying the oil in the hydraulic cylinders, which had become somewhat thickened by the low temperature. The ten rounds were fired without mishap of any kind in twelve minutes and twenty-one seconds, the pawls catching each time on the sixteenth notch, and the piece, upon tripping them, returning entirely to the firing position. The gun detachment consisted of one noncommissioned officer and nine men. The time might have been somewhat reduced if the detachment had not been required to take cover at each round.

CONCLUSIONS.

(1) With full charge and 37,000 pounds counterweight the piece recoils to the lowest position and returns fully to the firing position.

(2) Eighty pounds is the least charge with which the piece with 37,000 pounds counterweight recoils sufficiently far for the pawls to catch.

(3) With the counterweight reduced to 33,500 pounds the charge may be reduced to 65 pounds and insure the catching of the pawls, the piece not returning fully to the firing position and having to be heaved forward by the pinching bars at an expense of about twenty seconds time. As reduced charges are only used in practice firing, this time is not important. For lighter charges additional fulcrum pins would have to be provided.

(4) The piece can be loaded at any position at which the pawls engage.

(5) It is considered by the board that the test of this carriage has demonstrated that it possesses in a marked degree the properties which should pertain to a disappearing carriage for high-power guns.

It is simple in construction, so that its parts and their purposes are easily understood.

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Loading and maneuvering are effected by operations which are accomplished by hand with ease, certainty, and great rapidity, and these operations simulate very closely those required with the barbette carriages already adopted by the Department.

No valves or pumps of any kind are required, a feature regarded by the board as very desirable, as it insures certainty that the carriage will at all times be in proper working order and ready for action.

The fact that the entire test of the carriage, involving the firing of 47 rounds, was conducted without the breaking of a part or the bending of a bolt, indicates great care and skill on the part of the designer in proportioning its parts and adjusting them to the work which they were intended to perform.

While the carriage as it stands is considered by the board in all respects fit for use in the service, it might be modified to advantage by adding a more efficient counter-recoil buffer, and by increasing the facilities for hauling down by hand, and the depths of the well for counterweight might be diminished by using lead instead of iron for the counterweight.

Firing record and photographs showing the piece in the loading and firing position are inclosed.

It is understood that the Department is already in possession of full drawings.

CLIFTON COMLY,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

NOTE.—By authority of the Chief of Ordnance Capt. Crozier was, at his own request, relieved from duty with the board in rendering the above report.

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Record of firing with 8-inch B. L. rifle (steel), No. 1 type, Watervliet Arsenal,

[Object of firing, test of Buffington

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Recoil.
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*	*Ft. In.*
Nov. 14	1	252	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	25	*264 †7	Cored shot rebanded.	300	202.90	10 00	F, 2,500 G, 3,000	6 2½
Nov. 14	2	253		50	*528 †7		297	202.90	10 00	F, 9,000 G, 9,000	.....
Nov. 14	3	254		75	*792 †7		297	202.90	10 00	Not taken.	.....
Nov. 15	4	255		40 45 85	423 470—7		298	202.80	10 00	Not taken.	4 0
Nov. 15	5	256		50 50 100	529 524—7		298	202.80	10 00	F, 30,800 G, 31,600	4 1
Nov. 15	6	257		55 60 115	585 629—7		296	202.90	10 00	F, 32,060 G, 31,964	4 3
Nov. 15	7	258		61 62 123	647 651—7		296	202.90	10 00	F, 32,123 G, 32,092	Not taken.
Nov. 15	8	259		63 62 125	668 651—7		296	202.90	10 00	F, 32,292 G, 32,543	4 4½
Nov. 15	9	260		64 63 127	679 661—7		295	202.90	10 00	F, 42,000 G, 40,860	4 4½
Nov. 15	10	261		62 63 125	658 660—7		298	202.80	10 00	F, 33,580 G, 33,520	4 6½
Nov. 15	11	262		62 63 125	657 662—7		297	202.90	10 00	F, 34,880 G, 34,780	4 7
Nov. 15	12	263		62 63 125	657 661—7		295	202.90	10 00	F, 34,600 G, 34,480	4 5

*Brown. †Black.

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at Sandy Hook Proving Ground, November 14 to December 14, 1893.

Crozier disappearing carriage.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.			
.....	Wind from right and front, 15° 4 miles an hour; barometer, 30.14; thermometer, 52°; humidity, 63.	Loaded at 10½° elevation, easily, by 3 men. Arms, 7 inches from buffers. No counter recoil in this round. Uncompressed copper cylinders and tables of 1890.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea. Counterweight, 37,000 pounds. The arms of crane for hoisting the projectile are slightly too long to allow projectile to swing close enough to breech to be rammed easily. In the first round fired on carriage the gun did not raise quite to firing position, and was embarred to that position by hand. In every case noted where gun did not raise to firing position the gun was embarred to that position by hand. In rounds 2 and 3 of carriage there was some counter recoil, which prevented the recoil from being measured. A marker for indicating recoil was put on before next firing. Before this firing the handles for raising counterweight were lengthened by forging pieces of pipe to their ends, and were bent outward slightly to enable men to work more easily. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....		Arms, 13½ inches from buffers when loaded. Loaded at 13° 47′, 4 men on rammer. Gun did not raise quite to firing position. Copper cylinders of 9,000 pounds initial compression and tables of 1890.	
.....		Arms, 9½ inches from buffers when loaded. Loaded at 13° elevation. Gun came up within 4½ inches of firing position. Gun recoiled and then came back within 9 inches of buffers.	
3 3		Distance of gun from firing position after raising, not noted.	
2 6		Gun in raising came within 21 inches of buffers. Copper cylinders of 24,000 pounds initial compression and tables of 1890.	
2 4	Barometer, 29.77; thermometer, 43; humidity, 55.	Gun in raising came within 8 inches of buffers. Copper cylinders of 24,000 pounds initial compression and tables of 1890.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea. Copper cylinders of 32,000 pounds initial compression and tables of 1892. The carriage as built was not provided with counter-recoil buffers. To prevent shock in raising to firing position, a rubber buffer, encircling piston, was put on in front. A brass index was also put on over elevating gear wheel, to indicate elevation or depression of gun. The counterweight consists of 33,000 pounds cast weights and 4,000 pounds of lead in pigs of 100 pounds each. In cases when the gun did not recoil sufficiently far to allow the pawls to engage in the racks in front, the gun was pulled down to the loading position by the steam capstan. The gun was generally pulled down so that the pawl engaged in the tenth or eleventh notch in the rack.
.....		Gun in raising came within 19½ inches of buffers. Three lead pigs removed before this round before raising. Counterweight, 36,700 pounds.	
2 10		Gun in raising came within 6½ inches of buffers.	
3 2½		Gun loaded 7½ inches from buffers. Five lead pigs removed before raising. Counterweight, 36,200 pounds. Gun in raising came within 8 inches of buffers.	
2 5½		Seven lead pigs removed before this round. Counterweight, 35,500 pounds. Leakage of oil at stuffing boxes of both cylinders. Stuffing boxes tightened. Distance of gun from firing position after raising, not noted.	
2 8		Five lead pigs removed before this round before raising. Counterweight, 35,000 pounds. Gun loaded 6 inches from buffers. Gun in raising came within 23 inches of buffers.	
2 2		500 pounds removed from counterweight, leaving 34,500 pounds. Gun loaded 6 inches from buffers. Gun in raising came within 23½ inches of buffers.	

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Record of firing with 8-inch B. L. rifle (steel), No. 1 type, Watervliet Arsenal,

[Object of firing, test of Buffington-

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Recoil.
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*	*Ft. In.*
Nov. 15	13	264	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	62 63 125	657 662—7	Cored shot rebanded.	298	202.90	10 00	F, 35,660 G, 35,066	4 7
Nov. 15	14	265		62 63 125	657 662—7		298	202.90	10 00	F, 45,800 G, 47,044	4 7
Nov. 22	15	266		38 37 75	397—7 394		298	202.90	10 00	N, 18,050	4 5
Nov. 22	16	267		63 62 125	669 658—7		296	202.90	10 00	M, 36,080	4 9½
Nov. 22	17	268		62 63 125	653 669		296	202.90	10 00	N, 38,080	4 10½
Nov. 22	18	269		62 63 125	657 661—7		296	202.90	10 00	M, 32,846	4 10
Nov. 22	19	270		62 38 100	661 404		296	202.90	10 00	Less than 32,000.	4 9
Nov. 22	20	271		63 27 90	661—7 287		297	202.90	10 00	Less than 34,000.	4 8
Nov. 28	21	272		37 63 100	392 662—7		295	202.90	10 00	F, 34,700	4 9
Nov. 28	22	273		62 63 125	657 663—7		297	202.90	10 00	F, 33,046	4 10

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at Sandy Hook Proving Ground, November 14 to December 14, 1893—Continued.

Crozier disappearing carriage.]

Counter recoil.	Wind. strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.			Copper cylinders of 32,000 pounds initial compression and tables of 1892.
2 7	.....	500 pounds removed from counterweight, leaving 34,000 pounds. Gun loaded 6 inches from buffers. Gun came within 28½ inches of buffers in raising.	Before this firing the curved pipes on top of reservoir opening to the air had three thicknesses of wire screen put in their lower ends, to prevent the overflow of oil as the gun was coming up to firing position. This, however, did not stop the oil from coming out of reservoir.
1 1	.....	1,000 pounds removed from counterweight, leaving 33,000 pounds. Gun loaded 6 inches from buffers. Gun in raising came within 29½ inches of buffers.	Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
4 4	Barometer, 29.81; thermometer, 46°; humidity, 92.	Counterweight, 37,000 pounds. Gun loaded at 6 inches from buffers. Copper cylinders of 18,000 pounds initial compression and tables of 1890.	
.....		Gun loaded at 6 inches from buffers. Time to raise from loading to firing position, 4 seconds. Gun in recoiling came within 11½ inches of buffers; caught on ninth tooth in rack.	Gun mounted on Buffington-Crozier disappearing carriage.
.....		Five lead pigs removed before this round and before raising. Counterweight, 36,500 pounds. Gun in raising came within 2½ inches of buffers, having started from ninth tooth in rack. Gun in recoiling came within 8½ inches of buffers; caught in eleventh tooth of rack, and heaved down by levers to the fourteenth tooth.	Obturating friction primers. Fired to sea. The loading crane was shortened 9 inches before this firing, enabling projectile to be swung near breech, and to be more easily rammed. The dust pan was not a good fit, and bound very hard on nuts of holding-down bolts. It was removed before this firing.
.....		Five more lead pigs removed before this round. Counterweight, 36,000 pounds. Gun in raising came within one-half inch of buffers. Time of recoiling, 1 second. Gun in recoiling came within 8½ inches of buffers; caught in eleventh tooth; heaved down by levers to the fourteenth tooth.	The throttling bars were removed before this firing, and the areas of the orifices were all increased 10 per cent.
.....		Gun in raising came within 2 inches of buffers. Time of raising, 5 seconds. Time of traversing carriage from right to left; gun down (4 men), 1 minute 14½ seconds. Average, 72 turns a minute. The gun was traversed through 54°; caught on sixth tooth, 13⅜ inches from buffers.	Before this firing the "eyes" in the inside of the side pieces of the carriage were lowered as far as permitted, to enable hooks in blocks to engage, so as to bring block in a more advantageous position for hauling down the gun with a steam capstan.
.....		Gun in raising came within 2½ inches of buffers. Gun in recoiling caught in third tooth of rack.	
.....	Barometer, 29.82; thermometer, 52°; humidity, 81.	Counterweight, 36,500 pounds. Gun 9 inches from buffers when loaded. Gun in raising came within three-fourths inch of buffers. Five hundred pounds added to counterweight before firing, making it 37,000 pounds. Gun in recoiling caught in sixth tooth, 16 inches from buffers.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea.
.....		Gun loaded 16 inches from buffers. Gun came clear up into battery. Gun in recoiling caught in tenth tooth, 11 inches from buffers.	Since last firing the slots in piston head were sloped on each side of center 0.015 inch.

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Record of firing with 8-inch B. L. rifle (steel), No. 1 type, Watervliet Arsenal.

[Object of firing, test of Buffington

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Recoil.
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*	*Ft. In.*
Nov. 28	23	274	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	62 63	658 661—7	Cored shot rebanded.	299	202.90	10 00	N, 33,477	4 1½
				125							
Nov. 28	24	275		62 63	657 661—7		297	202.90	10 00	N, 32,300	4 11
				125							
Nov. 29	25	276		37 63	393 661—7		296	204.00	11 00	29,939	.....
				100							
Nov. 29	26	277		62 63	657 661—7		297	203.95	.....	35,700	.....
				125							
Nov. 29	27	278		62 63	657 661—7		297	203.95	.....	34,400	.....
				125							
Dec. 6	28	279		75 25	792 264—7		286	203.875	11 00	F, less than 28,000.	.....
				100							
Dec. 6	29	280		62 63	657 661—7		287	203.875	11 00	G, 33,400	.....
				125							
Dec. 6	30	281		63 17	661 180—7		295	203.875	11 00	F, 34,066	.....
				80							

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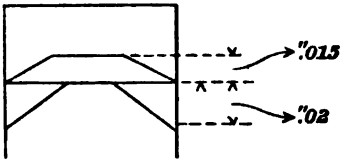
at Sandy Hook Proving Ground, November 14 to December 14, 1893—Continued.

Crozier disappearing carriage.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.			
.....	Barometer, 29.62; thermometer, 52°; humidity, 81.	Five lead pigs removed before this round. Counterweight, 36,500 pounds. Gun loaded 11 inches from buffers. Gun in recoiling caught in twelfth tooth, 7 inches from buffers. One of the pawls was not held back in front, and struck the rack as the gun was raising to firing position.	Time to traverse carriage from left to right, 54°, gun up; 2 men on handles, 1 minute 38½ seconds. Time to elevate gun from —5° to 14°. Gun down, 8¾ seconds (2 men).
.....		Five lead pigs removed before this round and before raising. Counterweight, 36,000 pounds. Gun in raising came within 3¾ inches of buffers. Gun in recoiling caught in thirteenth tooth, 5¾ inches from buffers. Before this firing the lower inside ends of pawls were cut off one-eighth inch, to permit them to be disengaged from rack more easily in moving gun by hand to loading position. The springs for these pawls were inclined to get rusty and work hard. The layer on left side of carriage for moving gun down was broken in the last attempt to move the gun down and was repaired before this firing. Before this firing the lead pigs were provided with handles, to enable them to be more easily changed by the men.	Time to depress gun from 14° to —5°, 4 men, 2 on each side, 18 seconds. Gun down. Gun in firing position: From —5° to 14°, 13¾ seconds; from 14° to —5°, 20 seconds. It requires 2 men on hand wheel to give elevation and 4 for depression. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....	Barometer, 30.18; thermometer, 53°; humidity, 63.	Gun loaded when pawl was engaging in eleventh tooth. Counterweight, 37,000 pounds. Gun in raising came up to within three-fourths inch of firing position. Gun in recoiling caught in sixth tooth.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea. Copper cylinder of 28,000 pounds initial compression and tables of 1890 used in round 276, and 32,000 pounds, copper, and tables of 1892 in rounds 277 and 278.
.....		Gun loaded as left from previous round. Gun in raising came up to within 5¾ inches of firing position. Five hundred pounds removed from counterweight after the gun was in firing position. Gun in recoiling caught in fourteenth tooth.	Before this firing, the slots in the piston head were changed as follows: The slot was cut down 0.015 inch, and then sloped each side of the center 0.02 inch.
.....		Gun loaded as left from previous round. Gun in raising came to within 4¾ inches of firing position. Gun in recoiling caught in fourteenth tooth.	
.....	Barometer, 30.41; thermometer, 41°; humidity, 68.	Counterweight, 37,000 pounds. Loaded when pawl was engaged in sixth tooth. Gun in raising came clear up into battery. Gun in recoiling caught in sixth tooth.	Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....		Three pigs removed before this round. Counterweight, 36,700 pounds. Loaded when pawl was engaged in sixth tooth. Gun in raising came within 1½ inches of buffers. Gun in recoiling came clear down to buffers; caught in sixteenth tooth. Elevation, 9° 45½'; measured when gun was down, after firing.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea.
.....		Gun loaded as left after previous round. Gun in raising came clear up to battery. Gun in recoiling caught in second tooth.	The time required to lower the gun by hand from the firing position to the loading position, the pawl engaging in the sixth notch, was 19 minutes 15 seconds.

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Record of firing with 8-inch B. L. rifle (steel), No. 1 type, Watervliet Arsenal,

[Object of firing, test of Buffington

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Recoil.
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*	*Ft. ls.*
Dec. 7	31	282	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	65	684 7	Cored shot rebanded.	291	206.875	11 00	.....	.....
Dec. 8	32	283		63 62	663—7 659		294	202.90	14 00	F, 36,400	.....
				125							
Dec. 8	33	284		62 63	660 663—7		291	202.90	5 00	G, 32,206	.....
				125							
Dec. 8	34	285		62 63	660 663—7		289	202.90	0 00	32,100	.....
				125							
Dec. 8	35	286		62 63	663 666—7		289	202.90	5 00	32,800	.....
				125							

[Object of firing, exhibition of carriage

A. M. Dec. 14	36	287	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	62 63	657 661+7	Solid shot, lot 446.	300	.....	10 00	.....	.....
				125							
Dec. 14	37	288		62 63	657 661+7	Cored shot, rebanded.	297	.....	10 00	.....	.....
				125							

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at Sandy Hook Proving Ground, November 14 to December 14, 1893—Continued.

Crozier disappearing carriage.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.			
.....	Barometer, 30.41; thermometer, 41°; humidity, 68.	Counterweight, 34,000 pounds. Gun loaded when pawl was engaged in sixth tooth. Gun in raising came within 26 inches of buffers. Gun in recoiling caught in first tooth on right side only. Before this firing, the slots in the piston heads were changed so as to make the depth of slots in center 1.48 inches, and at outer edges 1.50 inches. A new shot lift was made, so that the projectile was inclined at an angle of about 9°, to correspond with the gun. New fulcrum eyes were put on the front of each side piece, slightly lower than those on the carriage and nearer to the pawls. These enabled one man in each side to trip the pawls with ease, to enable the gun to rise to the firing position. An air hole was also drilled in the front end of each hydraulic cylinder, to prevent the formation of an air cushion.	This was done as follows: A block and tackle was attached to the arms, consisting of two 3-sheave blocks, and a luff tackle was used, consisting of two 2-sheave blocks. At first, 10 men were used, and then 2 men were added to this number. The distance between the blocks of the luff tackle when all the rope was played out required three purchases to be made before the gun was down. The time elapsed was from the instant that the men commenced to take off the counterweight until it was all put back again. The counterweight was 37,000 pounds, and the men had to remain and put back 4,000 pounds of this. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....	Barometer, 30.52; thermometer, 37°; humidity, 74.	Counterweight, 37,000 pounds. Gun loaded when pawl was engaged in the ninth notch. Gun came clear up to battery. Gun in recoiling caught in sixteenth notch.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea.
.....		Gun in raising came clear up to battery. Gun in recoiling caught in seventeenth notch, touching the buffers very gently.	When the gun is in the loading position, the pawl engaging in the seventeenth notch, the loading angle is 9° 3′.
.....		Gun in raising came clear up to buffers. After the gun was up, and before firing, 200 pounds added to counterweight. Gun in recoiling caught in seventeenth notch.	Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....		100 pounds added to counterweight before gun was raised. Gun in raising came clear up to battery. Gun in recoiling caught in seventeenth notch. Fired into sand butt, about 75 feet in front of gun. Projectile came out to the left, and struck the water about 500 yards from shore.	

before the Chief of Ordnance.]

.....	Barometer, 29.83; thermometer, 58°; humidity, 81.	Gun in raising came within 6 inches of battery. Gun in recoiling caught in fourteenth tooth.	Gun mounted on Buffington-Crozier disappearing carriage. Obturating friction primers. Fired to sea. Counterweight, 37,000 pounds. The cylinders of the carriage had been filled with neutral oil when the gun was in the loading position. This allowed too much oil to be put in, and this had to be forced out of the reservoir when the gun was allowed to come up to the firing position. The cold weather had made the oil somewhat thick, and these two facts probably account for the fact that the gun did not rise quite to the firing position. Firing conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.
.....		Gun in raising came clear up to battery. Gun in recoiling caught in sixteenth notch.	

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Record of firing with 8-inch B. L. rifle (steel), No. 1 type, Watervliet Arsenal,

[Object of firing, test of Buffington

Date.	No. of fire on carriage.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. No. of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.	Recoil
				Pounds.			*Pounds.*	*Inches.*	° ′	*Pounds.*	*Ft. In*
Dec. 14	38	289	Du Pont's brown prismatic V. U., lot 9; density, 1.850.	62 63	657 661+7	Solid shot, lot 446.	301	Not taken.	10 00	Not taken.	.....
				125							
Dec. 14	39	290		62 63	658 661+7		300	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	40	291		62 63	657 661+7		302	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	41	292		62 63	257 661+7		300	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	42	293		62 63	657 661+7		300	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	43	294		62 63	657 661+7		302	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	44	295		62 63	657 661+7		301	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	45	296		62 63	657 661+7		300	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	46	297		62 63	662 665+7	Cored shot, re-banded.	294	Not taken.	11 00	Not taken.	.....
				125							
Dec. 14	47	298		62 63	658 662+7		290	Not taken.	11 00	Not taken.	.....
				125							

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at Sandy Hook Proving Ground, November 14 to December 14, 1893—Continued.

Crozier disappearing carriage for rapidity.]

Counter recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Ft. In.			Gun mounted on Buffington-Crozier disappearing carriage.
.....	Wind from right and front 45°, 8 miles an hour.	.....	The carriage has a bypass and a check valve to hold the gun in place after recoiling. However, the bypass valve was kept open throughout the test of the carriage, permitting the return of the gun toward the firing position, provided the recoil was not sufficiently far to enable the pawls in front to engage in the rack.
.....		.....	
.....		.....	The recoil was measured on top rail of the right side piece by means of an indicator attached to the rear of the right hydraulic cylinder.
.....		.....	The channel on lower roller path, just under the flanges of the rollers, allows water to gather there and freeze, interfering with the movement of the rollers.
.....		.....	Obturating friction primers.
.....		.....	Fired to sea.
.....		.....	Counterweight, 37,000 pounds.
.....		.....	The gun in recoiling caught in the seventeenth notch.
.....		.....	The total time of firing these 10 rounds was 12 minutes 21 seconds, as follows:

	M.	S.
From the command "load" to first shot	1	07½
Between first and second shots.	1	29½
Between second and third shots.	1	12½
Between third and fourth shots.	1	07½
Between fourth and fifth shots.	1	15½
Between fifth and sixth shots	1	08½
Between sixth and seventh shots	1	20
Between seventh and eighth shots	1	13
Between eighth and ninth shots	1	19½
Between ninth and tenth shots.	1	06½

.....		.....	The command "load" was given when the gun was in loading position with the breechblock closed. The detachment at the gun consisted of 1 sergeant and 9 privates.
.....		.....	Firings conducted by Lieut. C. B. Wheeler, Ordnance Department, in the presence of the Ordnance Board. Present: Maj. C. Comly, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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APPENDIX 29.

TEST OF BUFFINGTON-CROZIER 10-INCH DISAPPEARING CARRIAGE.

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, September 8, 1894.

SIR: The following report of the test of the 10-inch Buffington-Crozier disappearing carriage is respectfully submitted:

The carriage is in all its essential features similar to the 8-inch Buffington-Crozier carriage described in report from this office dated December 29, 1893. It differs from the latter only in the following particulars: Its parts are made stronger and heavier in proportion to the increased caliber of the gun for which it is intended. For the better control of the movements of the gun, especially into battery, the chassis rails are inclined 3 degrees instead of being horizontal as in the 8-inch carriage. A special arrangement is provided for moving the gun from firing to loading position by hand. It consists of two drums mounted on a through shaft, at each end of which is a pinion engaging in a gear wheel worked by a crank. By means of this arrangement, in connection with blocks and tackle attached to the arms of the carriage, the gun can be hauled from battery, two men working at each crank handle.

The following programme was adopted for the test:

(1) As many rounds as may be necessary to be fired with varying charges and at any time during the test for making adjustments, etc., the amount of counterweight for each charge used being noted.

(2) The time for traversing, with gun up, through as many degrees as are permitted by the proof platform, and the number of men necessary, to be noted.

(3) The time for passing from elevation —5 degrees to +15 degrees and the reverse, with the gun up, and the number of men necessary, to be noted.

(4) The time for bringing from the firing to the loading position by hand and the number of men necessary, to be noted.

(5) The time for traversing, etc., as in No. 2, with the gun down, to be noted.

(6) The time for elevating, etc., as in No. 3. with the gun down, to be noted.

(7) The time for loading and the number of men necessary, to be noted.

(8) The time for raising from the loading to the firing position and the number of men necessary, to be noted.

(9) Five rounds to be fired with charges to be determined by the board, during which the following points will be noted:

(*a*) The tooth of the retaining ratchet caught by the pawl for each charge.

(*b*) The deficiency of counter recoil of the top carriage, if any, for each charge.

(*c*) The distance of the trunnions from the loading position for each charge.

(*d*) The time required, if any, for bringing from the recoil to the loading position, and the number of men necessary for each charge.

(10) One round with full charge to be fired at each of the elevations —5 degrees, 0 degrees, +5 degrees, +10 degrees, and +15 degrees.

(11) Ten rounds with full charges to be fired as rapidly as possible and the time noted.

(12) A target of ten shots to be made at the range, 3,000 yards, pointing by means of marks on the carriage.

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The carriage was assembled and the 10-inch Crozier wire-wound gun was mounted upon it in order that the rounds used in the test of the carriage might also be utilized in connection with the test of this system of wire construction.

The first 30 rounds were fired with varying charges for the purpose of making adjustments, and for testing certain samples of powder for the purpose of obtaining data for working up a powder suitable for the experimental gun used in this test. During these rounds the following adjustments were made: The pistons were removed three times and the depth of the slots increased 0.01 inch, 0.01 inch, and 0.015 inch, respectively, or 0.035 inch in all, the object being to increase the areas of the orifices for the flow of the liquid so as to insure a free and certain recoil of the gun to the proper loading position, with the counterweight reduced to the minimum weight consistent with a free and quick return of the gun into battery. For the same purpose the throttling bars were once removed, smoothed off, and reduced to uniform thickness. The form and dimensions of the shot crane were changed to facilitate loading—rope was substituted for the chain tackle, it having been found to work better with the 8-inch carriage. Screw eyebolts with square eyes were placed on the front of each chassis rail for use as fulcrums in tripping the pawls, thereby affording better leverage in this operation. New and improved tripping bars were provided. A shot tray was made to replace the tongs. It is so arranged that when suspended from the shot crane the tray is inclined at the loading angle most suitable.

With the throttling bars and slots as finally adjusted, the weight for the counterweight was found to be 66,787 pounds. During these 30 rounds the gun was fired at each of the angles −5 degrees, 0 degrees, +5 degrees, +10 degrees, and +15 degrees as required by the programme, also with reduced charges of 200 pounds, 180 pounds, 160 pounds, and 150 pounds, the last being the minimum charge which could be used with the certainty that the gun would be caught in recoil and held by the pawls engaging in the ratchet.

The rounds from 31 to 52 were fired for the purpose of testing the accuracy of the carriage at 3,000 yards. On the 14th of August, after 6 rounds firings were discontinued on account of the lateness of the hour, there being no prospect of completing the target on that day. On the 15th of August 4 rounds were fired, when a high and variable wind springing up it was necessary to discontinue the firing; the target was finally completed on the 17th of August, as noted in the record. This target was taken without the use of sights of any description, the pointing for direction being effected by means of pointer attached to the rear transom of the chassis and a mark on a brass strip attached to the rear traverse circle. For elevation the spur wheel of the elevating gear was graduated into degrees and minutes over that portion which would be used in these firings, the French quadrant being used in the operation to determine the angles. A pointer for this scale was attached to the left chassis rail. The resulting target, with respect to horizontal deviation, was excellent; the vertical deviation, however, was greater than the standard for a 10-inch gun. It should be remembered, however, that this is the first attempt to take a target under the conditions of pointing as above described, and there is no doubt that with the experience gained in these firings slight causes of deviation could be eliminated, and a second target could be made much better

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than that contained in the record. For comparison, a target should also be made using the best appliances which have heretofore been used in connection with accuracy firings with 10-inch rifles.

Rounds 53 to 66 were fired in connection with the test for rapidity, the first four being used to insure the perfect working of the system. The total time required was 22 minutes 19$\frac{9}{10}$ seconds, from which must be deducted 7 minutes 38 seconds, due to imperfect working of the breechblock of the gun as noted in the record, leaving the time actually required for the 10 rounds, 14 minutes 41$\frac{9}{10}$ seconds. The board has no knowledge of a record for rapidity equal to this. The standard heretofore for a 10-inch gun mounted on a disappearing carriage has been 10 rounds per hour. This standard must now be increased to 40 rounds for the same time.

During the course of the test the following observations were made as required by the programme:

	′	″
(2) Time for traversing, with gun up, through 48 degrees 56 minutes (all the proof platform admits), 2 men at each handle, 4 men in all	1	59½
(3) Time for passing from elevation, —4 degrees 20 seconds to +16 degrees, gun up, 2 men at each wheel, 4 men in all	0	31
From +15 degrees to —4 degrees 20 minutes	0	34½
(4) Time for bringing gun from firing to loading position, by hand, 4 men at each handle of the windlass and 1 at each fall, 10 men in all	11	33½
(a portion of this operation was performed with one block and tackle. See record).		
(5) Time for traversing, as in No. 2, gun down	2	5½
(6) Time for elevating, etc., as in No. 3, gun down—		
From —4 degrees 20 minutes to +16 degrees, 2 men, 1 at each wheel	0	30
From —4 degrees 20 minutes to +16 degrees, 4 men, 2 at each wheel	0	20
From +16 degrees to —4 degrees 20 minutes, 2 men, 1 at each wheel	0	54
From +16 degrees to —4 degrees 20 minutes, 4 men, 2 at each wheel	0	29
(7) Time for loading (from rapidity test), using 12 men (about)	0	67
(8) Time for raising the gun from loading to firing position, 2 men, 1 at each pawl	0	11½

CONCLUSIONS.

The advantages of this system of disappearing carriage are fully set forth in the report of the board on the 8-inch carriage before referred to. These advantages are confirmed and emphasized by the trial of a carriage adapted for a gun of much greater caliber and power, and it is the opinion of the board that the exhaustive test to which this system has now been subjected demonstrates that on account of the simplicity of its construction, involving no valves, pumps, or other complicated appliances, and the fact that by methods easily understood by the average artillery soldier the operations of loading and maneuvering are effected with remarkable ease, certainty, and rapidity, it is worthy of adoption for use in the service on all sites except those where an all-around traverse is absolutely necessary.

Some slight improvements might with advantage be applied to the carriage by making the piston rods pass out of the cylinders to the rear as well as to the front; the volume of metal within the cylinders would then be constant, which would do away with the necessity for the storage reservoir with its connecting pipes and valves. The chassis rollers should be placed nearer together; as at present arranged the top carriage, when passing from one set of rollers and just before reaching the next set, tends to tip forward very slightly, thus throwing its weight on the piston rods and springing them enough to cause a leak around the

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under portion of each during the latter part of the motion of the carriage into battery. This difficulty was to a great extent overcome in the present instance by turning the piston rods slightly eccentric at their forward ends where they pass through the supporting lugs, thus allowing the rods to conform somewhat to the variable motion of the top carriage. The inclination of the chassis rails should be about 2 degrees instead of 3 degrees. These changes, it is understood, the designer contemplates making in future constructions.

Firing records are forwarded herewith. It is thought that full drawings of this carriage are now on file in your office.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(1995)

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

[Object of firing, test of gun and test of Buffington-Crozier

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
		Kind.	Weight.	No. of prisms.	Kind.	Weight.			
			Pounds.			*Pounds*	*Inches.*	°	*Pounds.*
July 6	1	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	40 40 80	422 419+7	Solid shot, lot 537.	577	275.520	10	D, 10,200 Q, 10,958
July 9	2		80 80 160	844 837+7		575	275.670	10	D, 20,600 Q, 22,726

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Arsenal, at Sandy Hook Proving Ground, from July 6 to July 10, 1894.

experimental disappearing carriage for 10-inch B. L. rifle.]

Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Not enough to engage pawls.	Clear in battery.	Lead was added to the counterweight in 500-pound lots, and the pawls tripped after the addition of each lot until 3,500 pounds lead had been added; after 2,000 pounds had been added a hydraulic jack was used under the breech; the last lot of lead, 300 pounds, making 3,800 pounds lead and 66,800 pounds total counterweight, still failed to bring the gun in battery. The lead was removed and 2,000 pounds of cast iron (two semidisks) were added and 2,300 pounds of the lead replaced, making an increment of 500 pounds over the weight last tried. This was continued, the weight being increased by 500-pound increments, till 8,000 pounds cast iron and 3,300 pounds lead had been added, when gun ran in battery. The total counterweight was then 74,300 pounds. The lead was then removed, leaving the counterweight 71,000 pounds. The gun having run in battery gave an opportunity to clean and oil the rear chassis rollers and it was not expected that so much counterweight would be necessary on the next return to battery. After 3,000 pounds lead had been added to the original counterweight (making total counterweight 66,000 pounds), with the assistance of the hydraulic jack under the breech, the gun started but only moved a few inches and stopped again. This happened again, once or twice. As the result in each case was to decrease the length of the lever arm of the counterweight, it only served to increase the quantity of counterweight finally required. This is the principal reason why it was afterwards found necessary to decrease the counterweight to 70,900 pounds. Gun traversed by 7 men with comparative ease; afterwards by 5 men. Recoiled about two-thirds of the path. Projectile ricochetted once. Gun ran in battery against the buffers too hard, owing to cylinders being only partially filled. Traverse wheels raised from traverse circle by the blow. Upon attempting to close the breechblock the rotating handle came up hard against the locking pin, which had not been retracted by its spring. It was forced down with some difficulty. The burrs produced before the cause of the difficulty was discovered were removed; the pin taken out, freed from the rosin mixture with which it had been covered, and well oiled.	Gun mounted on Buffington-Crozier 10-inch disappearing carriage. Counterweight, 63,000 pounds at start. Obturating friction primers. 31 gallons of oil in cylinders for this round only. All bearings of carriage well oiled before gun was allowed to run in battery. The right pawl takes none of the counterweight, and it was necessary to use a plank as a battering ram to assist the lever in disengaging the left pawl. Fired to sea. Uncompressed copper cylinders and tables of 1890.
Not enough to engage pawls.	Clear in battery.	13 gallons of oil added in cylinders, making 44 in all. Gun brought back to loading position, by means of steam capstan, in 10 minutes. Elevation taken with gun in loading position. Gun loaded at 11° 44½′ elevation; shot rammed easily; 33 lead pigs added to counterweight; 4½ inches oil in reservoir cylinder with gun from battery. Breechblock closed with difficulty owing to the elevation of the gun. Gun ran in battery too hard; checked by by-pass valve. An escape of air from each cylinder when filling plugs were removed. 25 gallons of oil added in cylinders with gun in battery. Reservoir cylinder full to within 1 inch of the top. Total oil in system, 69 gallons. Gun pulled down by steam capstan to first notch in 7 minutes, and again allowed to run in, in order to adjust valve and regulate the velocity of the return in battery; the charge being light it was not expected that the pawls would engage, hence desirable to avoid too much velocity in the counter recoil. Gun traversed slightly with 4 men; recoil estimated at two-thirds of the path.	Copper cylinders of 14,000 pounds initial compression in Gauge D, and 18,000 pounds, coppers, Gauge Q. Tables 1892.

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

[Object of firing, test of gun and test of Buffington-Crozier

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
		Kind.	Weight.	No. of prisms.	Kind.	Weight.			
			Pounds.			*Pounds.*	*Inches.*	°	*Pounds.*
July 10	3	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	100 100 200	1, 055 1, 051+7	Solid shot, lot 537.	575	275.570	10	D, 32,015 Q, 31,871
July 10	4		120 120 240	1, 274 1, 270+7		575	275.570	10	D, 39,891 Q, 43,978
July 10	5		123 122 245	1, 299 1, 294+7		575	275.570	10	D, 45,578 Q, 46,689
July 10	6		119 123 242	1, 264 1, 302+7		575	275.570	10	D, 43,509 Q, 43,844
July 10	7		122 120 242	1, 296 1, 264+7		575	275.570	3	D, 42,491 Q, 43,911

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Arsenal, at Sandy Hook Proving Ground, from July 6 to July 10, 1894—Continued.

experimental disappearing carriage for 10-inch B. L. rifle.]

Recoil.	Counter recoil.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks
Not enough to engage pawls.	Clear in battery.	4,000 pounds cast iron removed from counterweight and 600 pounds lead added in securing proper adjustment. Total counterweight now, 70,900 pounds. Gun pulled down to nineteenth notch by means of capstan. Gun loaded at elevation 11° 56′. Shot rammed by 7 men. Thread on translating roller slightly burred, in several places cutting into thread on console; burrs dressed off and roller worked easily. 6 inches of oil in reservoir cylinder. Leak at left joint of equalising pipe. Plugs removed from filling holes; right cylinder full of oil; one-half gallon added in left. Carriage oiled thoroughly. Gun drawn from battery by capstan in 9½ minutes. Breechblock worked very easily. Copper cylinders of 28,000 pounds initial compression and tables of 1890.	
Fourth notch.	.....	Hauling-down tackle disconnected from carriage. Elevation at loading, 11° 58′. Powder chamber not sponged. Shot rammed hard (7 men). Time in elevating from loading to firing position, 14 seconds. Gun did not run all the way in battery; bars used in ratchets to force it in remaining inch. Traversed by 5 men.	
Fifth notch.	.....	Chamber sponged. Attempt made to load gun at elevation of 16° 32′; pawls in fourth pair of teeth proved unsuccessful, projectile falling to platform. The inability to load at this angle is due to the fact that the projectile has to be raised so nearly against the arm of the loading crane that the tackle no longer admits the requisite swing for entering the projectile in the chamber. Gun pulled down from fourth to nineteenth notch by capstan and loaded at 12° elevation. Right stuffing box tightened one turn and left stuffing box one-half turn. Time required to run in battery, 38 seconds; failed by 4 inches to run in battery, bars used as before; 1½ gallons oil, less 1 pint, added in cylinders.	Copper cylinders of 32,000 pounds initial compression and tables of 1892 in Gauge O, and 40,000 pounds, copper, and tables of 1893 in Gauge Q.
Fifth notch.	.....	Gun pulled down by capstan to nineteenth notch. Left equalizing pipe joint tightened. Chamber sponged. Gun loaded at 11° 52′. Gun ran to within 4 inches of "in battery" in 15 seconds. Bars used to move gun balance of way in battery.	For rounds 5 to 6, inclusive, copper cylinders of 40,000 pounds initial compression and tables of 1893.
Sixth notch.	.....	Gun brought down from fifth to nineteenth notch by means of capstan. Chamber sponged. Gun loaded at 11° 58′. Gun ran within 8 inches of "in battery" in 12 seconds; forced in balance of way by bars. Oil leaked out of stuffing boxes in a stream as gun ran in battery. One-half turn taken on right and one-third turn on left stuffing box. Shot ricochetted to the right. Gun allowed to run in battery to place screens for velocity firing. Oil withdrawn from cylinders to permit alteration in slots in piston-heads. 66 gallons saved.	Copper cylinders of 32,000 pounds initial compression and tables of 1892.

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Number stenciled on base.	Travel of shot in bore.	Elevation.	Instrumental velocity, 275 feet from muzzle.
			Lbs. Oz.			*Lbs. Oz.*		*Inches.*	° ′	*Feet.*
P. M. July 14	8	Du Pont's brown prismatic, W. H., lot 7; density, 1.860.	120 0 122 0 242 0	1,277 1,287+7	Solid shot, lot 837.	575 0	12	275.670	1 51	1,968 1,960
July 14	9	Du Pont's brown prismatic, V. U., lot 17; density, 1.850.	120 0 125 0 245 0	1,250 1,293+7		575 0	10	275.570	1 51	1,972 1,968
A. M. July 16	10		132 0 135 8 267 8	1,371 1,404+7		575 0	11	275.370	1 51	1,981 1,981
P. M. July 16	11	Du Pont's brown prismatic, V. U., lot 16; density, 1.845.	123 0 122 0 245 0	1,324 1,307+7		575 0	14	275.670	1 51	1,945 1,935

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Arsenal, at Sandy Hook Proving Ground, from July 14 to August 7, 1894.

Pressure per square inch of bore.	Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.				
D, less than 40,000. Q, 44,420	8	Wind from right and rear, 15°, 10 miles an hour; barometer, 29.98; thermometer, 88°; humidity, 52.	Since last firing the piston rods have been removed and the slots each deepened 0.01 inch. They were also turned slightly eccentric (0.03 inch) at their forward ends, where they pass through the supporting lugs. The leaks around the stuffing boxes occurred on the under portions of the rods only, and only when the gun was nearly in battery. This was caused by the top carriage tipping forward very slightly just before reaching the next pair of chassis rollers, thus throwing the weight on the piston rods and springing them enough to cause a leak around the under portion of each during the last 18 inches of the path while running in battery. 75 gallons oil in cylinders; cylinders filled with gun from battery until there were 5¼ inches oil in reservoir cylinder; 1⅛ inches space in cylinder above surface of oil. Loaded with pawls in 19-inch notch. Elevating band moved forward 3⅜ inches in order to decrease loading angle. Gun ran in battery in 13 seconds. About 3 gallons ran out when gun ran in battery; too much oil in cylinders; 70 gallons is just about right. Rear end of spindle marked; spindle did not rotate.	Fired into sand butt No. 1. Copper cylinders of 40,000 pounds initial compression and tables of 1893 used in rounds 8 and 10, and copper cylinders of 32,000 pounds initial compression and tables of 1890 used in rounds 9 and 11.
D, less than 32,000. Q, 34,018	6		Gun pulled down by capstan from 4th to 19th notch. Chamber sponged. Shot rammed easily by 7 men. Breechblock could not be closed owing to too great length of cartridge. Cartridge shortened, powder charge remaining the same. Breech now closed easily; gun ran in battery in 10 seconds. Oil leaked from stuffing boxes around under portion of piston rods during last 18 inches as the gun ran in battery.	
D, less than 40,000. Q, 45,340	9	Wind from front and right, 10° 5 miles an hour; barometer, 30.21; thermometer, 73°; humidity, 78.	Gun drawn from battery from 9th to 19th pair of ratchet teeth by means of capstan. Chamber sponged thoroughly. Oil leaked from cylinders at under side of rods as in preceding round. Spindle turned to left about 5° upon firing. Gun forced in battery last one-half inch. Shot came out of butt and fell on top.	
P, less than 32,000. U, 39,740	8		Gun pulled down by capstan to 19th pair of ratchet teeth. Right upper bolt holding plate to gun levers was found broken; about seven-eighths of it looks like an old break. Pad was found spreading clear over split ring. Breechblock could not be closed. Pad was soft so that it could easily be indented with the fingers, the spread-over portion was pressed back with a stick and breech closed. Gun ran in battery in 10 seconds. Just a small leak at bottom of piston rod when reached 1 foot of "in battery." Projectile came out of butt, fell to right and toward gun. Elevating arms vibrated considerably.	

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Number abandoned on base.	Travel of shot in bore.	Elevation.	Instrumental velocity, 275 feet from muzzle.
			Lbs. Oz.			*Lbs. Oz.*		*Inches.*	° ′	*Feet.*
P. M. July 16	12	Du Pont's brown prismatic. W. H., lot 3; density, 1.860.	127 0 127 0 254 0	1,357 1,349+7	Solid steel, lot 527.	575 0	13	275.570	1 51	1,939 Lost.
July 16	13	Du Pont's brown prismatic. V. U., lot 16; density, 1.845.	126 0 127 0 253 0	1,353 1,353+7	Solid steel, lot 527.	575 0	15	275.620	1 51	1,979 1,977 175+$\frac{28}{32}$
July 21	14	Du Pont's brown prismatic. W. H., lot 7; density, 1.860.	121 0 121 0 242 0	1,296 1,273+7	Solid steel, lot 527.	578 0	.....	275.470	10 0	.....

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at Sandy Hook Proving Ground, from July 14 to August 7, 1894—Continued.

Pressure per square inch of bore.	Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.				Copper cylinders of 40,000 pounds initial compression and tables of 1893 used in rounds 12 and 13. Velocities taken by Lieut. F. P. Peck, Ordnance Department, U. S. Army. Copper cylinders of 40,000 pounds initial compression and tables of 1893 used in round 14. Fired to sea. Since last firing the following changes have been made: The slots in the piston heads have each been deepened 0.01 inch. The arm of the shot crane has been shortened slightly and the curvature decreased in order to cause the projectile to swing closer to the breech and permit it to be inserted when higher (see remark round 5). A washer has been placed in the bottom of the socket for the shot crane, and this bearing has been still further improved by easing the pivot and drilling an oil hole. Guards have been placed over each of the two pulleys on the arm of the shot crane to prevent the rope from leaving the pulleys in swinging the projectile to the breech of the gun. The drum of the shot crane has been covered with sheet brass, covering the helical groove in its surface and thereby increasing its capacity beyond the requirements of service conditions, a step rendered necessary by the increased lift demanded at the proving ground. Rope, having been found more satisfactory tackle for this gear, was substituted for chain. Screw eye-bolts, square eyes, have been placed, one on the front of each chassis rail for use as fulcrums in tripping the pawls. They are so located as to considerably increase the leverage on the pawls, as well as on the bars used to trip them. Sheet-iron rings have been placed, one on each piston rod in rear of the baletta buffers to prevent the latter from following the stuffing boxes back when the gun recoils. New bars have been made for tripping the pawls. A shot tray to take the place of tongs has been made. It is attached to its handle at such an angle that when suspended from the shot crane the tray is inclined at the loading angle.
O, 42,436 U, 42,600	8	Wind from front and left, 30°, 8 miles an hour; barometer, 29.88; thermometer, 77°; humidity, 74.	Gun pulled down from eighth to nineteenth notch by capstan. Revetment repaired before firing this round. Elevation of carriage changes slightly on firing. Gun ran to within 1 inch of "in battery" in 11 seconds. Small leak under piston rod as gun ran last foot of "in battery." Projectile came out of butt toward gun, striking about 100 yards to right of same. Spindle did not rotate. Elevating arms did not vibrate. The pad is apparently in as good condition as ever it was.	
O, 45,840 U, 46,540	8	Wind from front, 0°, 9 miles an hour; barometer, 30.21; thermometer, 71°; humidity, 86.	Gun pulled down to nineteenth notch by capstan. Sand butt filled in. Gun ran clear in battery in 9 seconds. Chassis changed direction very slightly as gun ran in battery. Elevating arms vibrated considerably. Spindle did not rotate. Shot came out of butt and fell on top. After this round gun pulled back to nineteenth notch by capstan and oil taken out of cylinders to deepen slots in piston heads. The heads of the blank plugs are larger than those of the pressure gauges, so that the same wrench does not fit both. After this round gun entirely cleaned, inspected, and found in a perfect condition.	
O, 44,660 U, 44,380	9		70 gallons oil in cylinders. Left upper bolt holding plate to gun lever found broken before this firing. 900 pounds lead removed from the counterweight, leaving the total counterweight now 70,000 pounds. Gun drawn from battery from ninth to sixteenth pair of ratchet teeth by means of steam capstan. Projectile rammed and gun allowed to run "in battery" in order to set by-pass valve. Gun ran in battery just right. By-pass valve was on arrowhead. Gun drawn from battery till pawls engaged in nineteenth pair of ratchet teeth, by means of steam capstan, and the charge inserted. After discharge the breech block rotated easily and opened without difficulty.	

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Number stenciled on base.	Travel of shot in bore.	Elevation.	Instrumental velocity, 275 feet from muzzle.
			Lbs. Oz.			*Lbs. Oz.*		*Inches.*	° ′	*Feet.*
July 21	15	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	120 0 120 0 240 0	1,275 1,266+7	Solidshot, lot 537.	577 8	.....	.....	0 0	275.570
July 23	....		.....	.....		.....	.....	.....	.....	.....
July 27	16		119 0 119 0 238 0	1,263 1,252+7		576 8	.....	.....	15 0	275.570
July 27	17		119 13½ 0 2½ 117 13½ 0 2½ 238 0	1,264 Musket powder. 1,248 Musket powder.	Solid shot, lot 502.	576 8	.....	Not taken.	2 0	.....
July 31	18		119 13½ 0 2½ 119 13½ 0 2½ 240 0	1,267 Musket powder. 1,267 Musket powder.	Solid shot, lot 537.	577 0	.....	275.470	15 0	.....
July 31	19		119 13½ 0 2½ 119 13½ 0 2½ 240 0	1,267 Musket powder. 1,269 Musket powder.		577 0	.....	275.470	2 0	.....
Aug. 2	....		.....	.....		.....	.....	.....	.....	.....

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at Sandy Hook Proving Ground, from July 14 to August 7, 1894—Continued.

Pressure per square inch of bore.	Recoil pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.				
{ O. 43,527 U. 43,564	{ 10	.....	Gun ran in battery just right. Projectile ricochetted twice. Breechblock worked easily in opening.	Copper cylinders of 40,000 pounds initial compression and tables of 1893.
.....	.....	.....	Oil withdrawn from cylinders. Piston rods and throttling bars removed and taken to machine shop.	Fired to sea.
{ O. 43,867 U. 43,582	{ 9	Wind from front and right, 5°, 2 miles an hour; barometer, 30.31; thermometer, 80°; humidity, 76.	With the pawls engaged in the tenth pair of ratchet teeth and the gun as left by the recoil from the last round (fired with an elevation of 0°) the loading angle was found to be 11° 17′. The projectile was rammed at this angle. The gun was then drawn from battery by the steam capstan till the pawls engaged first in the sixteenth and later in the nineteenth pair of ratchet teeth. The corresponding loading angles were 9° 50′ and 8° 43′, respectively. The gun was then allowed to run in battery to adjust the by-pass valve.	Fired to sea. 69 gallons oil put in cylinders; no overflow when gun ran in battery. Since last firing the following changes have been made. The throttling bars were found to differ from each other and the cross sections of a given bar were found to be irregular. The slots in the piston heads were found to be irregular also. The thinnest of the throttling bars was selected and the remaining three were made to conform to it. The maximum reduction in thickness in any case was 0.02 inch (on one bar for about 1 foot of its length). The slots in the piston heads were made uniform also; their common depth now is 1.58 inches. The maximum thickness of metal removed was about 0.01 inch. Copper cylinders of 40,000 pounds initial compression and tables of 1890.
			Gun elevated to 15°. Drawn from battery to nineteenth pair of teeth. Elevation in this position 10° 5′. Charge inserted.	
			With the pawls in a given pair of ratchet teeth the loading angle varies with the elevation for which the gear is set. The upper end of either elevating arm never reaches the center of the circular path of the corresponding elevating rack in consequence of the wedges added on top of the chassis rails after the circular paths were located, and this causes the variation in the loading angle. Elevating arms vibrated considerably.	
{ O. 40,891 U. 41,760	{ 11		Shot ricochetted twice. Oil withdrawn and piston rods removed after this round.	
{ O. 41,036 U. 41,109	{ 13	Wind from front and right, 45°, 5 miles an hour; barometer, 30.12; thermometer, 88; humidity, 68.	Gun ran in battery in 9½ seconds. Leak discovered around two of the bolts holding the left throttling bar in place in right cylinder and around one bolt in right bar of left cylinder as gun ran "in battery." Bolts tightened before firing this round. Gun traversed by 6 men.	69 gallons neutral oil put in cylinders. Since last firing each slot in the piston heads has been deepened 0.02 inch. The chassis rails are inclined upward to the rear 3°. The traverse circle was found not horizontal during last firing. It has been partially but not wholly corrected. Fired to sea. Copper cylinders for rounds 18 and 19, 40,000 pounds initial compression and tables of 1893.
{ O. 41,780 U. 42,364	{ 18		Gun loaded with pawls in thirteenth pair of ratchet teeth. Oil still leaked around one bolt in left throttling bar of right cylinder. Inclination of gun levers with gun in battery 12° to the rear of the vertical. Gun thoroughly cleaned, inspected, and found in good order.	
.....	.....		The elevating band was found to have moved forward perhaps 0.01 inch; the clamping nut was tightened one-twelfth of a turn.	

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Number stenciled on base.	Travel of shot in bore.	Elevation.	Instrumental velocity 275 feet from muzzle.
			Lbs. Oz.			*Lbs. Oz.*		*Inches.*	° ′	*Feet.*
Aug. 6	20	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	119 13½ 0 2½ 119 13½ 0 2½ 240 0	1,268 Musket powder. 1,267 Musket powder.	Solid shot, lot 537.	576 8	.....	275.370	5 0	.....
Aug. 6	21		119 13 0 3 119 13 0 3 240 0	1,273 Musket powder. 1,264 Musket powder.	Solid shot, lot 502.	577 0	.....	Not taken.	0 0	.....
Aug. 6	22		119 12½ 0 3½ 119 12½ 0 3½ 240 0	1,274 Musket powder. 1,271 Musket powder.	Solid shot, lot 537.	575 0	.....	275.570	10 0	.....
Aug. 6	23		119 12 0 4 119 12 0 4 240 0	1,274 Musket powder. 1,274 Musket powder.		576 0	.....	275.370	5 0	.....
Aug. 7	24		119 11½ 0 4½ 119 11½ 0 4½ 240 0	1,266 Musket powder. 1,272 Musket powder.		577 0	.....	Not taken.	2 0	.....

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at Sandy Hook Proving Ground, from July 14 to August 7, 1894—Continued.

Pressure per square inch of bore.	Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such an effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Pounds.				
O, 41,817 U, 42,168	14	Wind from front and right, 15°, 10 miles an hour; barometer, 30.27; thermometer, 80°; humidity, 44.	Gun traversed by 4 men	
O, 42,640 U, 42,680	16		Gun loaded with pawls in fourteenth pair of ratchet teeth.	
O, 42,982 U, 43,156	13		Gun loaded with pawls in sixteenth notch. Ran in battery in 9½ seconds, striking against buffers rather hard. Gun allowed to run in battery to admit of obtaining proper depression to fire into sand butt on beach specially constructed for the purpose.	
O, 42,720 U, 43,320	16		Fired into sand butt on beach prepared for that purpose. Shot remained in butt. The stops which limit the motion of the elevating gear permit only 4° 20′ depression. They were located with reference to horizontal chassis rails. The upward slope of 3° finally given these rails permits a greater depression. When this round was fired the stops were removed and the gun depressed 5°. The stops were afterwards replaced.	Fired to sea. Rounds 20, 21, 22, and 24. Another bolt out of transom joining gun levers, making 3 in all. Copper cylinders of 40,000 pounds initial compression and tables of 1893 used in rounds 20 to 24, inclusive.
O, 43,320 U, 43,178	14	Wind from front, 0°, 7 miles an hour; barometer, 30.16; thermometer, 81°; humidity, 58.	Two gallons of oil added in cylinders to compensate for leakage. Nut on elevating band tightened. Oil withdrawn from cylinders to permit alteration in slots in piston heads.	

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

Date.	No. of fire.	Powder. Kind.	Weight.	Number of prisms.	Projectile. Kind.	Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs. Oz.*	*Inches.*	° ′	*Pounds.*
Aug. 10	25	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	119 14	1,276 Musket powder.	Solid shot, lot 537.	576 0	275.470	10 0	Q, 43,644 U, 43,527
			2						
			119 14	1,277 Musket powder.					
			2						
			240 0						
Aug. 10	26		119 14	1,276 Musket powder.		578 0	275.470	4 0	Q, 43,156 C, 42,640
			2						
			119 14	1,276 Musket powder.					
			2						
			240 0						
Aug. 10	27		99 13½	1,058 Musket powder.		572 0	275.470	4 0	Q, 31,939 U, 31,942
			2½						
			99 13½	1,056 Musket powder.					
			2½						
			200 0						
Aug. 10	28		89 14	949 Musket powder.		576 8	275.470	4 0	Q, 27,000 U, 26,327
			2						
			89 14	954 Musket powder.					
			2						
			180 0						
Aug. 10	29		79 14	843 Musket powder.		576 0	275.470	4 0	Q, 22,627 U, 22,523
			2						
			79 14	840 Musket powder.					
			2						
			160 0						
Aug. 11	30		74 13½	797 Musket powder.		577 8	275.470	4 0	Q, 20,277 U, 20,106
			2½						
			74 13½	793 Musket powder.					
			2½						
			150 0						

[To test accuracy of

Aug. 14	31	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	119 13½	1,264 Musket powder.	Solid shot, lot 537.	575 0	275.370	2 38	Q, 43,600 U, 43,156
			2½						
			119 13½	1,264 Musket powder.					
			2½						
			240 0						
Aug. 14	32		119 13½	1,273 Musket powder.		575 0	275.570	2 30	D, 41,500 R, 42,730
			2½						
			119 13½	1,274 Musket powder.					
			2½						
			240 0						

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Arsenal, at Sandy Hook Proving Ground, from August 10 to August 17, 1894.

Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
17	Wind from front and right, 30°, 8 miles an hour; barometer, 30.14; thermometer, 75°; humidity, 47.	Seventy gallons of oil put in cylinders. Copper cylinders of 40,000 pounds initial compression and tables of 1893.	Since last firing, slots in piston head deepened 0.015-inch. Two ground joints and one solder joint which were leaking in pipes leading from reservoir cylinder to piston rods, have been repaired. Left pawl lowered slightly to permit the right one to bear part of the weight. Levers for tripping pawls lengthened by sliding on a piece of pipe. One man trips each pawl now without difficulty. The central column of prisms was omitted and an igniter of rifle powder inserted the full length of each charge. Fired to sea.
20		Copper cylinders of 40,000 pounds initial compression and tables of 1893.	
11		Ten pigs of lead removed from counterweight (1,000 pounds), before gun was allowed to run in battery. Gun ran in too hard; throttling had to be increased. Decided hang fire. Copper cylinders of 28,000 pounds initial compression and tables of 1890.	
8		Five more pigs of lead (500 pounds), removed from counterweight before gun was allowed to run in battery. Slight hang fire. Elevation did not change upon firing this round. With the service charge it changes slightly. Copper cylinders of 24,000 pounds initial compression and tables of 1890.	
3		Hung fire slightly. Copper cylinders of 18,000 pounds initial compression and tables of 1892.	
2	Wind front and right, 7 miles an hour; barometer, 30.27; thermometer, 76°; humidity, 41.	Five more pigs of lead (500 pounds) removed from counterweight. With pipes on the levers and 3 men on each pipe the piece was forced from battery one pair of teeth—from third to fourth. Shot entered with difficulty. After firing, the gun was forced from battery by hand from the second to the nineteenth pair of teeth by 7 men on each lever. Decided hang fire. Gun cleaned, inspected, and found in good order after this round.	

arriage at 3,000 yards.]

20	Wind from left and front, 30°, 10 miles an hour.	Twenty-five pigs of lead (2,500 pounds) added to counterweight. Aimed at the left edge of the target. Misfire—primer exploded, but failed to ignite charge. Miss—340 yards to rear and 25 feet to right of the line (the gun is not visible from the 3,000 yards target, and it is difficult to locate the line of fire in consequence. Judging from the results of following rounds there is no doubt that this shot was a good line and missed over only). Struck recoil buffers a pretty hard blow.	Fired at 3,000 yards target. Before this firing the gun was aimed on the left edge of the 3,000 yards target, using bore sights, and the direction was recorded by means of a pointer attached to the rear transom of the chassis, and a mark on a brass strip attached to the rear traverse circle.
19	Wind from left and front, 15°, 10 miles an hour.	Four pigs of lead added in this round. Aimed 52 feet to the left of left edge of target. Miss—150 yards to rear and 18 yards to left. Struck recoil buffers, but not so hard as in previous round. Came near taking twentieth pair of teeth and came back to nineteenth pair. Distance from gun levers to recoil buffers, 1¼ inches after this round.	

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet Arsenal,

[To test accuracy of

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Lbs. Oz.			*Lbs. Oz.*	*Inches.*	° ′	*Pounds.*
Aug. 14	33	Du Pont's brown prismatic W. H., lot, 7; density, 1.860.	119 13½ 119 13½ 240 0	1,267 Musket powder. 1,267 Musket powder.	Solid shot, lot 537.	573 0	275.470	2 30	Q, 42,680 U, 42,311
Aug. 14	34		119 13½ 119 13½ 240 0	1,269 Musket powder. 1,271 Musket powder.		573 0	275.370	2 30	D, 42,311 R, 43,200
Aug. 14	35		119 13½ 119 13½ 240 0	1,274 Musket powder. 1,272 Musket powder.	Solid shot, lot 513.	577 0	275.470	2 30	Q, 43,564 U, 43,527
Aug. 14	36		119 13½ 119 13½ 240 0	1,273 Musket powder. 1,270 Musket powder.		576 0	275.470	2 27½	D, 41,500 R, 42,720
Aug. 15	37		119 13½ 119 13½ 240 0	1,274 Musket powder. 1,276 Musket powder.		576 8	275.570	2 27½	Q, 42,018 U, 42,927
Aug. 15	38		119 13½ 119 13½ 240 0	1,274 Musket powder. 1,266 Musket powder.		577 0	275.570	2 27½	D, 42,760 R, 43,111
Aug. 15	39		119 13½ 119 13½ 240 0	1,272 Musket powder. 1,267 Musket powder.	Solid shot, lot 537.	575 8	275.570	2 30	Q, 42,740 U, 42,891
Aug. 15	40		119 13½ 119 13½ 240 0	1,267 Musket powder. 1,270 Musket powder.		575 0	275.570	2 33	D, 42,780 R, 42,909
Aug. 15 and 17	41		119 13½ 119 13½ 240 0	1,265 Musket powder. 1,274 Musket powder.		576 0	275.570	2 30	Q, 42,038 U, 42,244
Aug. 17	42		119 13½ 119 13½ 240 0	1,273 Musket powder. 1,272 Musket powder.		577 0	275.470	2 38	D, 40,891 R, 42,289
Aug. 17	43		119 13½ 119 13½ 240 0	1,274 Musket powder. 1,268 Musket powder.		577 0	275.470	2 40	Q, 43,123 U, 43,300
Aug. 17	44		119 13½ 119 13½ 240 0	1,273 Musket powder. 1,271 Musket powder.		577 0	275.570	2 40	D, 40,877 R, 40,964

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at Sandy Hook Proving Ground, from August 10 to August 17, 1894—Continued.

carriage at 3,000-yards.]

Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
19	Wind from left and front, 15°, 10 miles an hour.	Aimed 32½ feet to left of left edge of target. Miss—140 yards to rear and 6 yards to left. Gun ran in battery a little too hard; throttling increased.	
19	Wind from left and front, 30°, 10 miles an hour.	Aimed at left edge of target. Struck target 8 feet above, 9 feet left. Gun ran in battery a very little too hard: throttling increased.	
19	Wind from left and front, 40°, 8 miles an hour.	Aimed at left edge of target. Miss—high and to left. Gun ran in battery a little harder; throttling increased. Block rotated with slight difficulty on opening.	The spur wheel of the elevating gear was graduated in degrees from 0° to 15°, both inclusive, and the elevations 2° 27′, 2° 33′, 2° 38′, and 2° 43′ were added, using the old French quadrant. The angle between 2° 38′ and 2° 43′ was afterwards graduated to minutes by dividing the corresponding arc into five equal parts. A pointer for this scale was attached to the chassis rail; 0.0519 of an inch of arc on the rear traverse circle measures an angle of 1′ at its center.
19	Wind from left and front, 35°, 8 miles an hour.	Aimed at left edge of target. Struck target 5 feet below, 13 feet left. Gun ran in battery too hard; throttling increased. Block rotated with greater difficulty on closing.	
16	Wind from front and right, 20°, 6 miles an hour.	Four gallons of oil added in cylinders. Aimed 10 feet to the right of left edge of target. Missed target 10 or 15 yards to the left.	
17	Wind from front and right, 20°, 8 miles an hour.	Three pigs of lead removed from counterweight. Aimed 25 feet to the right of left edge of target. Struck target 14½ feet below, 3½ feet right. Two gallons of oil added in cylinders.	All the firing at the 3,000 yards target was done by means of the foregoing graduations and data.
17	Wind from front and right, 15°, 15 miles an hour.	Ten pigs of lead removed from counterweight. Aimed as in previous round. Struck target 12 feet below, 5 feet right.	Two gallons of oil added in cylinders.
19	Wind from front and right, 15°, 18 miles an hour.	Five pigs of lead removed from counterweight. Aimed 20 feet to the right of left edge of target. Struck target 6 feet below, 3½ feet right.	Copper cylinders of 40,000 pounds initial compression and tables of 1893.
19	Not fired; wind 21 miles an hour; firing suspended. (17th): Wind from front and left, 70°, 3 miles an hour.	Firing suspended on account of wind. Charge withdrawn after gun was in battery. Charge inserted again August 17, with the gun still in battery. One quart of oil added in cylinders. Struck 75 feet in front, ricochetted through target 8 feet below, 4 feet left.	Barometer, 30.18; thermometer, 77°; humidity, 71.
19	Wind from left, 90°, 3 miles an hour.	Struck target 10.5 feet below, 1 foot right.	The leak at the joint of the equalizing pipe with left cylinder noted in round 3 has not been repaired and has been getting worse. This caused the increased throttling found necessary yesterday. About a pint of oil is forced out through this leak each time the gun runs in battery, thus increasing the recoil.
20	Wind from front and left, 15°, 3 miles an hour.	First shot on target.	Rounds 37, 38, 39, 40, barometer, 29.99; thermometer, 82°; humidity, 72.
20	Wind from front and left, 9°, 3 miles an hour.	.....	Rounds 41 to 44, inclusive, aimed at left edge of target.
			Rounds 41, 42, 43, 44, barometer, 30.12; thermometer, 75°; humidity, 51.

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle

[To test accuracy of

Date.	No. of fire.	Powder. Kind.	Weight.	Number of prisms.	Projectile. Kind.	Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Lbs. Oz.			*Pounds.*	*Inches.*	° ′	*Pounds.*
Aug. 17	45	Du Pont's brown prismatic W. H., lot 7; density, 1.800.	119 13½ 2½ 119 13½ 2½ 240 0	1,265 Musket powder. 1,270 Musket powder.	Solid shot, lot 537.	577	275.570	2 40	C, 43,300 U, 42,945
Aug. 17	46		119 13½ 2½ 119 13½ 2½ 240 0	1,268 Musket powder. 1,273 Musket powder.		577	275.470	2 40	D, 40,545 R, 41,740
Aug. 17	47		119 13½ 2½ 119 13½ 2½ 240 0	1,274 Musket powder. 1,273 Musket powder.		577	275.470	2 40	C, 43,013 U, 42,222
Aug. 17	48		119 13½ 2½ 119 13½ 2½ 240 0	1,268 Musket powder. 1,270 Musket powder.		576	275.470	2 40	D, 40,400 R, 42,091
Aug. 17	49		119 13½ 2½ 119 13½ 2½ 240 0	1,263 Musket powder. 1,272 Musket powder.		576	275.320	2 42	C, 43,400 U, 43,290
Aug. 17	50		119 13½ 2½ 119 13½ 2½ 240 0	1,267 Musket powder. 1,273 Musket powder.		576	275.420	2 42	D, 40,182 R, 41,600
Aug. 17	51		119 13½ 2½ 119 13½ 2½ 240 0	1,265 Musket powder. 1,271 Musket powder.		575	275.470	2 43	C, 43,380 U, 43,360
Aug. 17	52		119 13½ 2½ 119 13½ 2½ 240 0	1,264 Musket powder. 1,274 Musket powder.		575	275.370	2 43	D, 40,055 R, 41,600

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Watervliet Arsenal, at Sandy Hook Proving Ground, August 17, 1894.

carriage at 3,000 yards.]

Recoil, pair of ratchet teeth (notch.)	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
20	Wind from front and right, 60°, 3 miles an hour.	Struck buffers very gently coming down.	
19	Wind from front and right, 15°, 3 miles an hour.	Two and one-half gallons of oil added in cylinders. Three men to rotate block on closing.	Aimed at left edge of target. Copper cylinders of 40,000 pounds initial compression and tables of 1893. Barometer, 30.14; thermometer, 83°; humidity, 43.
20	Wind from front and right, 20°, 3 miles an hour.	Struck recoil buffers gently. Waited about one-half hour between rounds 46 and 47 for vessels to pass.	
20	Wind from front and right, 5°, 5 miles an hour.	Five pigs of lead added to counterweight before firing this round and removed immediately after.	
18	Wind from front and right, 15°, 10 miles an hour.	Two gallons (minus) oil added in cylinders. Five bolts out on left side of transom holding gun levers together. Delay of about one-half hour waiting for vessels to pass. Head wind freshening considerably. Projectile lighter. Elevation increased.	
20	Wind from front and right, 15°, 10 miles an hour.		
20	Wind from front and right, 15°, 8 miles an hour.	.....	
20	Wind from front and right, 15°, 6 miles an hour.	Three pigs of lead added to counterweight before firing round No. 52.	

TARGET.

Number of round.	From center of target. Vertical. Above.	From center of target. Vertical. Below.	From center of target. Horizontal. Right.	From center of target. Horizontal. Left.	From center of impact. Vertical. Above.	From center of impact. Vertical. Below.	From center of impact. Horizontal. Right.	From center of impact. Horizontal. Left.
43	3.5	....	....	6	8.25	....	....	0.2
44	5	....	....	8	9.75	....	....	2.2
45	....	2.5	....	6	2.25	....	....	0.2
46	....	2	....	1	2.75	....	4.8	....
47	....	13	....	5.5	....	8.25	0.3	....
48	....	5.5	....	6.5	....	0.75	....	0.7
49	....	6	....	6	....	1.25	....	0.2
50	....	10	....	4	....	5.25	1.8	....
51	....	5	....	7	....	0.25	....	1.2
52	....	12	....	8	....	7.25	....	2.2

Center of impact—	Feet.
Below	4.75
Left	5.8
Mean vertical deviation from center of impact	4.6
Mean horizontal deviation from center of impact	1.38
Mean deviation from center of impact	4.8
Center of impact from vertical plane through axis of gun, right	14.2

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle,

Date.	No. of fire.	Powder.			Projectile.		Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
		Kind.	Weight.	Number of prisms.	Kind.	Weight.			
A. M.			*Lbs. Oz.*			*Pounds.*	*Inches.*	° ′	*Pounds.*
Aug. 21	53	Du Pont's brown prismatic W. H., lot 7; density, 1.800.	119 13½ 2½	1,272 Musket powder.	Solid shot, lot 537.	576	275.370	10 20	Q, 41,883 U, 42,018
			119 13½ 2½	1,264 Musket powder.					
			240 0						
Aug. 21	54		119 13½ 2½	1,270 Musket powder.		577	275.370	10 20	D, 41,410 R, 42,344
			119 13½ 2½	1,267+6 Musket powder.					
			240 0						
Aug. 21	55		119 13½ 2½	1,274 Musket powder.		574	275.370	10 20	Not taken.
			119 13½ 2½	1,275 Musket powder.					
			240 0						
Aug. 21	56		119 13½ 2½	1,267 Musket powder.		576	275.370	10 0	Not taken.
			119 13½ 2½	1,272 Musket powder.					
			240 0						

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Watervliet Arsenal, at Sandy Hook Proving Ground, August 21, 1894.

Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
18	Wind from left and rear, 20°, 8 miles an hour; barometer, 30.12; thermometer, 69°; humidity, 59.	Cylinders filled. About one quart lost by overflow when gun ran in battery.	Before this firing the following repairs and changes were made: The translating roller was found burred by the locking pin of the tray latch. The burrs were removed and the bearing of the pin was enlarged so as to ride over the screw threads without danger of engaging therein. The oil was removed from the cylinders and an effort made to repair the leak in the joint between the equalizing pipe and the left cylinder. The leak was diminished, but not wholly stopped. The handle of the translating roller was lengthened to 10 inches by fitting a sleeve over it in order to afford room for 2 men to grasp it. This was found desirable, due to the necessity of always closing the block with the gun at a considerable elevation (the loading angle). This sleeve was removed for firing.
19		One gallon of oil added in cylinders. Six black prisms used in base of cartridge in addition to the central igniter. The transom joining the gun levers was removed before this round was fired. So many of the bolts were broken that one end of it was entirely detached from the gun levers, and it was found to be unnecessary anyhow.	
17		.....	
17		.....	Copper cylinders of 40,000 pounds initial compression and tables of 1893. Fired to sea.

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle,

[Test carriage

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
P. M.			*Lbs. Oz.*			*Pounds.*		°	
Aug. 21	57	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	119 13½	1,268	Solid shot, lot 537.	576	Not taken.	10	Not taken.
			2½	Musket powder.					
			119 13½	1,277					
			2½	Musket powder.					
			240 0						
Aug. 21	58		119 13½	1,267		575	Not taken.	.....	Not taken.
			2½	Musket powder.					
			119 13½	1,266					
			2½	Musket powder.					
			240 0						
Aug. 21	59		119 13½	1,270		577	Not taken.	.....	Not taken.
			2½	Musket powder.					
			119 13½	1,270					
			2½	Musket powder.					
			240 0						
Aug. 21	60		119 13½	1,267		575	Not taken.	.....	Not taken.
			2½	Musket powder.					
			119 13½	1,272					
			2½	Musket powder.					
			240 0						
Aug. 21	61		119 13½	1,273		576	Not taken.	.....	Not taken.
			2½	Musket powder.					
			119 13½	1,272					
			2½	Musket powder.					
			240 0						
Aug. 21	62		119 13½	1,266		576	Not taken.	.....	Not taken.
			2½	Musket powder.					
			119 13½	1,266					
			2½	Musket powder.					
			240 0						

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Watervliet Arsenal, at Sandy Hook Proving Ground, August 21, 1894.

for rapidity.]

Recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Not noted.	Wind from left and rear, 35°, 13 miles an hour; barometer, 30.11; thermometer, 75°; humidity, 37.	.....	
Not noted.		.....	
Not noted.		.....	
Not noted.		.....	
Not noted.		About half a gallon of water was thrown into the chamber before loading, to soften the residue. The water sizzled when it struck the metal.	Counterweight, 69,400 pounds. Started with the breechblock open; loading tray in gun; first charge on truck near gun; projectile on platform and not in carrier. The remaining charges were stored about 85 feet from the gun in rear of a traverse, and were kept covered with a paulin. The projectiles were all on the platform.
Not noted.		About half a gallon of water was thrown into the chamber before loading to soften the residue. The water sizzled when it struck the metal. The breechblock could not be rotated after closing. It was withdrawn and the spindle and lock nuts were loosened slightly; it was then rotated but with some difficulty. The trouble was probably caused, mainly, by the spindle nut being tightened through turning the spindle in removing the obturating primers from the vent. The primers were inserted and removed while the breechblock was out. In thus removing a primer which has been upset by the discharge, it is possible to turn the spindle and tighten the nut. The loading crane is so arranged that the projectile is swung to the breech of the gun with its axis at right angles to that of the gun and then revolved until these axes are coincident. Due to the hasty loading, the point of the projectile struck against the interior of the breech plate while making this revolution, in several instances producing burrs which interfered some with closing and still more with rotating the block, the burrs have since been removed. An other possible contribution to the sticking of the block was the expansion of the split rings in the direction of their thickness. They were quite hot, and the expansion may have been sufficient to force the frictionless disk hard back against the front of the block.	Twelve men served the gun, including bringing the powder from in rear of the traverse. The gun was not sponged throughout the firing.

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

[Test carriage

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
P. M.			*Lbs. Oz.*			*Pounds.*		°	
Aug. 21	63	Du Pont's brown prismatic W. H., lot 7; density, 1.860.	119 12½ 2½ 119 13½ 2½	1,275 Musket powder. 1,274 Musket powder.	Solid shot, lot 537.	575	Not taken.	.....	Not taken.
			240 0						
Aug. 21	64		119 13½ 2½ 119 13½ 2½	1,268 Musket powder. 1,272 Musket powder.		575	Not taken.	.....	Not taken.
			240 0						
Aug. 21	65		119 13½ 2½ 119 13½ 2½	1,276 Musket powder. 1,265 Musket powder.		575	Not taken.	.....	Not taken.
			240 0						
Aug. 21	66		119 13½ 2½ 119 13½ 2½	1,271 Musket powder. 1,270 Musket powder.		577	Not taken.	.....	Not taken.
			240 0						

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Arsenal, at Sandy Hook Proving Ground, August 21, 1894—Continued.

for rapidity.]

Recoil.	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Not noted.	Wind from left and rear, 35°, 13 miles an hour; barometer, 30.11; thermometer, 75°; humidity, 87.	.....	The elevation changed less than one minute in firing the ten rounds. After this firing the gun was cleaned and inspected. The lands seem to be worn away considerably on the forcing cone, especially in the upper half of the bore. Otherwise the gun appears to be in good condition and shows little erosion.
Not noted.		.....	TIME REQUIRED TO FIRE TEN ROUNDS.
Not noted.		.....	
Not noted.		The primer was forgotten till after the breechblock was closed, thus causing considerable delay in this round.	

	Minutes.	Seconds.
From command "load" to first round	1	20½
From first round to second round	1	22
From second round to third round	1	22
From third round to fourth round	1	18½
From fourth round to fifth round	1	19½
From fifth round to sixth round	1	34
From sixth round to seventh round	1	43½
From seventh round to eighth round	1	27½
From eighth round to ninth round	1	24½
From ninth round to tenth round	1	50
Actual time to fire ten rounds	14	41 3/10
Time to loosen spindle nuts and for vessels to get out of the way	7	38
Total time from command "load" till the last of the ten shots was fired	22	19 3/10

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Record of firing with 10-inch Crozier wire wound B. L. steel rifle, Watervliet

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Powder. Number of prisms.	Projectile. Kind.	Projectile. Weight.	Travel of shot in bore.	Elevation.	Pressure per square inch of bore.
			Lbs. Oz.			*Pounds.*	*Inch.*	°	*Pounds.*
Aug. 24	67	Du Pont's brown prismatic V. W. H., lot 7; density, 1.860.	119 13½	1,274 Musket powder.	Solid shot, lot 537.	575	Not taken.	10	Q, 41,364 U, 41,489
			119 13½	1,276 Musket powder.					
			240 0						
Aug. 28	68	Du Pont's brown prismatic V. U., lot 16; density, 1.845.	119 13½	1,273 Musket powder.		576	275.200	10	D, 40,000 R, 40,720
			119 13½	1,285 Musket powder.					
			240 0						

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Arsenal, at Sandy Hook Proving Ground, from August 24 to August 28, 1894.

Recoil, pair of ratchet teeth (notch).	Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
17	Barometer, 30.24; thermometer, 68°; humidity, 72.	Gun star gauged after this round.....	Fired to sea. The counterweight is composed of 9 cast-iron disks which were meant to weigh 7,000 pounds each; 4 cast-iron semi-disks which were meant to weigh 1,000 pounds each, and 24 pigs of lead supposed to weigh 100 pounds each. The records of the quantity of counterweight used up to date have been made up on the above basis. The shipping list shows the cast-iron portion of the counterweight to weigh 64,675 pounds instead of 67,000 pounds, indicated by the above data. The average weight of the lead pigs, determined by weighing 10, is 88 pounds. The actual weight of the counterweight, as finally adjusted, is 66,787 pounds instead of 69,400 pounds, as stated in round 57. Copper cylinders of 40,000 pounds initial compression and tables of 1893.
17	Barometer, 30.09; thermometer, 76°; humidity, 66.	2½ gallons of oil added in cylinders. The solder joint at the right end of the copper pipe leading from the reservoir cylinder to the piston rod is leaking again.	

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AUGUST 31, 1894.

GUN "IN BATTERY."

To determine time for elevating the gun from $-5°$ to $+15°$, and the reverse:
The actual limits of elevation with the present location of the stops are $-4°\ 20'$ and $+16°$.
Greater depression can be secured by removing the stops: (*See* Remarks round 23.)
The gun was depressed from $+15°$ to $-4°\ 20'$ in 34¼ seconds and was elevated from $-4°\ 20'$ to $+16°$ in 31 seconds, by two men at each handwheel, 4 men in all.
To determine time for traversing the gun:
The gun was traversed through an angle of $48°\ 56'$ (all the proof platform admits) in 1 minute 59½ seconds, by two men working on each handle, 4 men in all.
To determine the time required to draw the gun from battery by hand:
Two tackles were used for this purpose, one on each side. Two blocks of 3 sheaves each were used in each tackle. Each fall was led to its own drum on the geared windlass which constitutes a part of the carriage.
Ten men were employed—4 on each handle of the windlass and 1 on each fall. The eye of the upper block on left side broke at the end of 3 minutes and 38 seconds. The gun was drawn from battery the remaining distance by the tackle on the right, in order to proceed with other details of the programme while the block was being repaired. Time not noted.

GUN "FROM BATTERY."

To determine time required to traverse the gun:
The gun was traversed through an angle of $48°\ 56'$ (all the proof platform admits) by 4 men on each handle, 8 men in all, in 2 minutes 5¼ seconds.
To determine time required for elevating the gun from $-4°\ 20'$ to $+16°$ and the reverse:
Elevated in 30 seconds by 2 men, 1 on each handwheel.
Depressed in 54½ seconds by 2 men, 1 on each handwheel.
Elevated in 20 seconds by 4 men, 2 on each handwheel.
Depressed in 29 seconds by 4 men, 2 on each handwheel.
To determine the time required for the gun to run "in battery":
Done in 11¼ seconds.
One man tripped each pawl, 2 men in all.
The time was kept by the president of the Ordnance Board.

SEPTEMBER 1, 1894.

GUN "IN BATTERY."

To determine time required to draw gun from battery by hand:
The tackles used and their arrangement were the same as yesterday. Ten men were employed; 4 on each handle of the windlass and 1 on each fall.
The eye of the upper block on the left side again broke; this time at the end of 4 minutes and 29 seconds. This eye was considerably smaller than that of the right block. The left tackle was disengaged and the gun drawn back the remaining distance by the right tackle alone in 7 minutes 4½ seconds. The men were distributed as before except that 2 men were on the fall of the remaining tackle.

	Minutes.	Seconds.
Total time from start till gun was "from battery" (the pawls in the 20th pair of ratchet teeth)	14	58
Less delay caused by removing left tackle	3	24¾
Time consumed in drawing gun from battery	11	33¼

None of the counterweight was moved for this operation.
The time was kept by the president of the Ordnance Board.
Firing conducted in the presence of the Ordnance Board. Present: Maj. F. H. Phipps, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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APPENDIX 30.

PROGRESS REPORT ON TEST OF BROWN 5-INCH WIRE GUN.

(1 plate.)

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
Governors Island, N. Y. H., May 10, 1894.

SIR: The following progress report of the test of the 5-inch Brown segmental wire gun is respectfully submitted:

It is understood that complete drawings of the gun are on file in the Ordnance Office, but the following figures are given for ready reference:

Weight of gun	tons..	3.75
Number of segments		12
Length of powder chamber	inches..	47.5
Diameter of powder chamber	inches..	5.25
Weight of projectile	pounds..	60
Travel of shot	inches...	172.5
Service charge	pounds..	31
Service velocity	foot-seconds..	2,300
Service pressure	per square inch—pounds..	40,000
Battering charge	pounds..	35
Battering velocity	foot-seconds..	2,500
Battering pressure	per square inch—pounds..	50,000
Stated elastic strength	per square inch—pounds..	63,000

The charges, velocities, and pressures are what were expected by the gun company to be obtained with brown powders.

The elastic strength is given as the pressure at the bore, which would reduce the pressure between the longitudinal segments to zero under the supposition that the liner should remain intact.

After correspondence with the trustees, the following programme for the first 500 rounds of the test was adopted:

(1) Twenty rounds, at the expense of the United States, to be allowed for the purpose of testing powder, making adjustments, etc., these rounds to be fired at any stage of the test that the company may desire.
(2) Twenty rounds to be fired with charges giving pressures of 36,000 to 40,000 pounds per square inch.
(3) Sixty rounds to be fired with charges giving pressures of 50,000 pounds per square inch, to be known as battering charges.
(4) Eighty rounds to be fired with charges giving pressures of 40,000 pounds per square inch, to be known as service charges.
(5) Twenty rounds to be fired with battering charges.
(6) Eighty rounds to be fired with service charges.
(7) Twenty rounds to be fired with battering charges.
(8) Eighty rounds to be fired with service charges.
(9) Twenty rounds to be fired with battering charges.
(10) Eighty rounds to be fired with service charges.
(11) Twenty rounds to be fired with battering charges.
(12) The company to be permitted to fire, at its own expense, whatever number of rounds it may desire for the purpose of testing powder, making adjustments, etc.,

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each round with pressure as high as 40,000 and less than 50,000 pounds per square inch to be considered a battering round of the test. Rounds with pressures less than 40,000 pounds per square inch not to be counted in the test.

(13) Charges giving pressures accidentally less than those established for service and battering charges by not more than 5 per cent may be counted as such charges.

(14) The company to be permitted to fire, in lieu of any battering charge, a charge giving a pressure greater than 50,000 pounds per square inch. Such round to be considered a battering round of the test.

(15) The angles of elevation to vary between 7 degrees depression and 20 degrees elevation, and to be determined by the board.

(16) The company to be permitted to insert, at its own expense, a chase lining in the gun at any stage of the test.

(17) The company to be permitted to renew, at its own expense, the lining tube whenever it may desire, the endurance and condition upon removal of each tube to be carefully noted.

(18) Should the breech mechanism fail, the company to be permitted to replace it, at its own expense, by a stronger one.

(19) The company to be permitted to change, at its own expense, the character of the gas check should the one provided be found unsuited to high pressures.

(20) The company to be permitted to use a lubricating wad, or other device designed to diminish erosion, at the base of the projectile.

(21) The gun to be star gauged after each relining, after each 100 rounds of the test, and at such other time as the board may direct.

(22) Velocities and pressures to be measured for a sufficient number of rounds to determine these elements for each charge and kind of powder.

The gun was mounted upon an old-style 8-inch casemate carriage altered for the purpose, and in accordance with the above programme the rounds exhibited by the inclosed table have been fired.

In the earlier rounds much difficulty was experienced with the pressure gauges, of which as many as five were sometimes used for the same round with great disagreement as to records. Some of the gauges were secured in the usual way and some were placed loose in the bore.

The records of pressure throughout the test exhibited much irregularity, varying often by 10,000 or 12,000 pounds in consecutive rounds with equal charges of the same kind of powder. In endeavoring to obtain a pressure of 50,000 pounds per square inch with brown powder, abnormal results were frequently obtained, the pressure rising from about 43,000 pounds per square inch to 70,000 or 80,000 pounds for a slight increase in the charge. The pressures thus recorded were undoubtedly in most cases wave pressures, and to reduce their intensity an igniter consisting of from 2 to 3 ounces of rifle powder, which was sewed in a long serge tube, was stretched throughout the length of the cartridge. With this the abnormal pressures were not so frequent, although they still occurred.

A wad of hair felt three-fourths of an inch thick, upon which was spread seven-eighths of an inch thickness of paraffin, was placed in rear of the projectile with the design on the part of the inventor of diminishing erosion.

Up to and including the eighty-seventh round the gas check used was a copper cup placed against the metallic head, taking the place of the usual mushroom head; after this round this was changed to the ordinary form of the de Bange gas check with split ring.

At the fifty-fifth round, which was with 32 pounds of brown prismatic powder, a mean pressure of 76,750 pounds was recorded, and the spindle was broken across at the inner end of the thread for the locking nuts. In this round the long igniter in a tube was not used. A new spindle was made.

At the one hundred and seventeenth round the spindle was again broken, the charge being 30 pounds of brown prismatic powder and the mean recorded pressure being 52,700 pounds per square inch.

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A new spindle was fitted to the old mushroom head, but at the one hundred and nineteenth round it was again broken, this time into three pieces, the charge being the same, i. e. 30 pounds of brown prismatic powder, and the recorded pressure 50,500 pounds per square inch. A new spindle was made which lasted until the suspension of the test.

After the fifty-fifth and one hundred and sixty-first rounds rubber impressions were taken of the portion of the bore in the vicinity and forward of the front end of the lining tube; the latter set shows a slight twisting of the lining tube and serious scoring forward of it, the joints between the staves being also distinctly marked.

The impressions are forwarded separately by express.

After the one hundred and ninety-second round, which was with a charge of 36 pounds of brown prismatic powder, giving recorded pressures of 50,956 pounds and 48,450 pounds in the two gauges used, two large cracks were discovered in the lining tube in the positions shown on the inclosed tracing. The upper crack is about one-quarter of an inch wide at its widest part and the lower one slightly narrower. A considerable quantity of gas escaped from under the front edge of the trunnion ring, which seems to have passed through the staves and wire, although it is possible for it to have passed around the rear ends of the staves, through the screw threads of the rear spool ring, and then through the wire. Impressions showing the cracks are forwarded by express.

The gun being rendered unserviceable, the test was suspended, and permission was given the company to remove it for dismantling and inspection by the board, which permission they have not yet availed themselves of.

Considerable interest attaches to the experiments with Leonard smokeless powder, which were made during the progress of the test, but which will not be dwelt upon here, attention only being invited to the one hundred and sixteenth round giving a velocity of 2,986 foot seconds, with recorded pressures of 40,100 and 40,240 pounds per square inch.

The breech mechanism, with the exception of the breaks of the spindle noted, worked satisfactorily throughout.

The final star gauging is not yet completed; the record will be forwarded later.

It is requested that the rubber impressions be returned to the Proving Ground for storage.

Firing record is sent separately by mail.

FRANK HEATH,
Captain, Ordnance Department, U. S. Army,
Senior Member Present.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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Rounds fired from 5-inch Brown segmental wire gun.

BROWN PRISMATIC POWDER.

Number of rounds.	Charge.	Average velocity.	Average pressure.	Number of rounds.	Charge.	Average velocity.	Average pressure.
	Pounds.				*Pounds.*		
1	12	1,217	12,000	1	36 1/8	2,069	29,700
2	20	1,603	17,500	1	37	2,229	33,000
10	25	1,750	30,000	1	37	2,311	48,000
1	26	.....	34,000	4	37 1/8	2,303	40,000
3	27	1,900	35,000	1	37 2/8	2,243	43,800
1	27	1,889	26,500	1	37 2/8	.....	50,500
1	28	.....	42,200	2	37 3/8	.....	.....
1	28 1/8	.....	38,500	2	37 3/8	.....	50,000
2	28 1/8	.....	38,500	1	37 4/8	.....	46,000
2	28	.....	47,000	1	37 4/8	2,247	37,500
2	28 1/8	.....	41,000	1	37 4/8	2,176	41,300
2	29	.....	40,000	1	37 5/8	.....	46,000
6	30	1,900	30,000	2	38	2,150	34,000
5	30	.....	45,000	13	38	2,340	50,000
3	30	2,100	50,000	1	38	2,008	.....
1	30	.....	60,000	1	38 2/8	.....	49,000
2	30	1,870	.....	1	38 2/8	2,157	40,000
3	31	2,082	44,000	1	38 2/8	2,254	55,000
3	31	.....	50,000	1	38 3/8	2,097	.....
2	31	.....	55,000	1	38 3/8	2,117	.....
8	31	.....	.....	2	38 4/8	.....	52,000
2	31 1/8	.....	50,500	1	38 4/8	.....	52,850
1	32	2,067	32,000	1	39	.....	46,800
2	32	2,110	42,000	1	39 1/8	.....	51,900
1	32	.....	76,500	3	39 2/8	.....	51,500
1	34	1,989	32,000	2	39 3/8	.....	55,500
4	35	2,100	32,000	4	39 4/8	2,328	50,000
3	35	2,230	36,000	1	39 4/8	.....	45,500
3	35	2,150	46,000	1	40 2/8	.....	43,500
1	35	2,282	65,400	1	40 3/8	2,428	43,650
2	36	2,100	40,000	1	46 1/8	2,380	48,300
1	36	.....	49,500				
1	36 1/8	2,172	36,500	Total..144	.....	.....	.....
5	36 1/8	2,200	40,000				

LEONARD SMOKELESS POWDER.

2	6	1,100	9,000	1	19	2,770	46,500
3	6	1,575	18,000	1	20	2,768	.....
3	7	1,600	15,000	1	21	2,839	46,600
1	7 4/8	1,690	19,100	1	24	2,088	40,000
1	8	1,697	16,000	1	25	1,798	28,000
1	8	1,917	64,000	1	25	2,629	34,600
2	9	1,800	16,150	1	25	2,755	39,500
2	11	2,000	23,000	1	25	2,450	.....
1	11	1,554	18,000	1	30	2,986	49,150
3	13	2,250	32,000	1	30	2,856	49,500
1	13 1/8	2,045	23,500	1	30	3,088	53,500
1	14	1,807	32,000	1	30	3,194	65,000
1	14	2,411	40,700	2	30	2,670	.....
1	15	1,548	14,024	1	32	2,508	29,800
1	15	1,932	17,150	2	32	3,000	50,000
1	15	2,368	33,000	1	34	2,976	48,000
2	15	2,100	.....	1	36	3,090	56,000
1	17	1,895	24,000				
1	17	2,490	35,000	Total..48	.....	.....	.....

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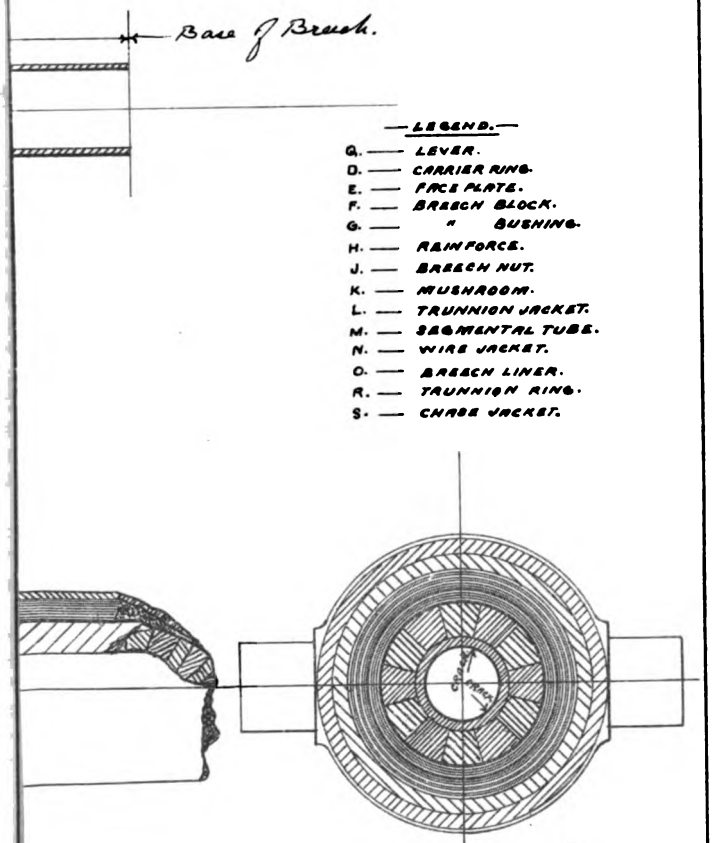

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APPENDIX 31.

REPORT UPON DISMANTLING BROWN 5-INCH WIRE WOUND GUN.

(2 plates.)

THE ORDNANCE BOARD, U. S. ARMY,
NEW YORK ARSENAL,
Governors Island, N. Y. Harbor, September 3, 1894.

The board has the honor to report that since May 10, last, the date of its progress report of tests of the 5-inch Brown segmental wire gun, the company has availed itself of the permission granted to remove the gun to its works for dismantling.

As previously reported, after the one hundred and ninety-second round the gun was found to be unserviceable; two large cracks were discovered in the lining tube and a considerable quantity of gas noticed escaping from under the front edge of the trunnion ring.

On the 3d of August, 1894, Maj. Frank H. Phipps and Capt. Frank Heath, of the board, proceeded under instructions to Bridsboro, Pa., to witness dismantling of the gun. Upon removing the jacket it was discovered that one of the segments had parted at about 34½ inches from the breech, the escaping gas had cut the wires at this point at every layer, leaving an opening about one-eighth of an inch wide, full width of the segment from lining tube to the space between wires and jacket. The escape of gas was thus accounted for. The bore was considerably eroded and scored, but the segments, with the one exception, were intact. Photographs of the tube and broken segment, showing crack and break, are herewith submitted. From the appearance of the fractured ends of the segment the board is of the opinion that the rupture took place sometime before the discovery of escaping gas, but how long before it has no means of determining.

The board is also of the opinion that no information could be obtained by a further test of this gun of sufficient importance to justify the expense required to put it in serviceable condition.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

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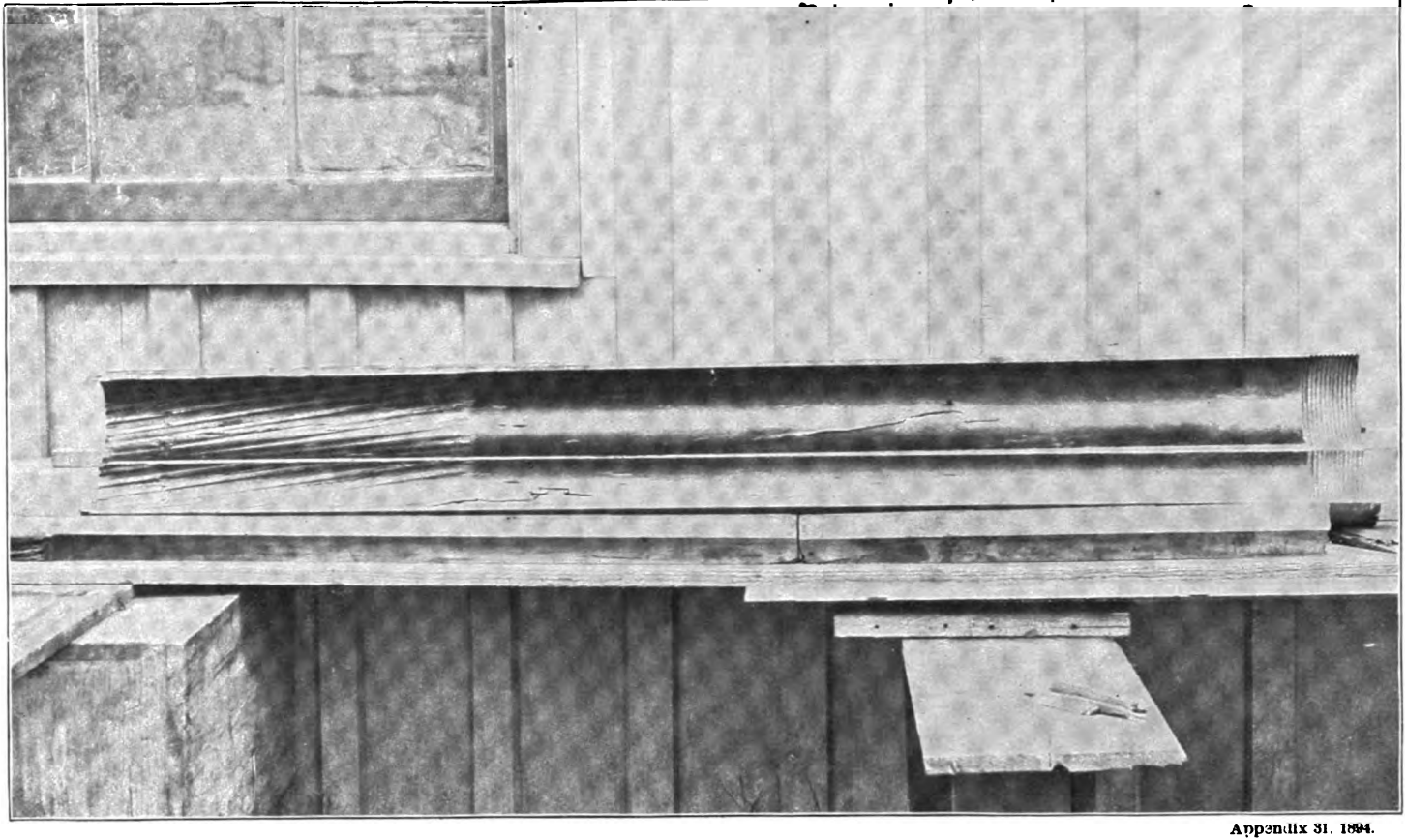

Appendix 31. 1894.

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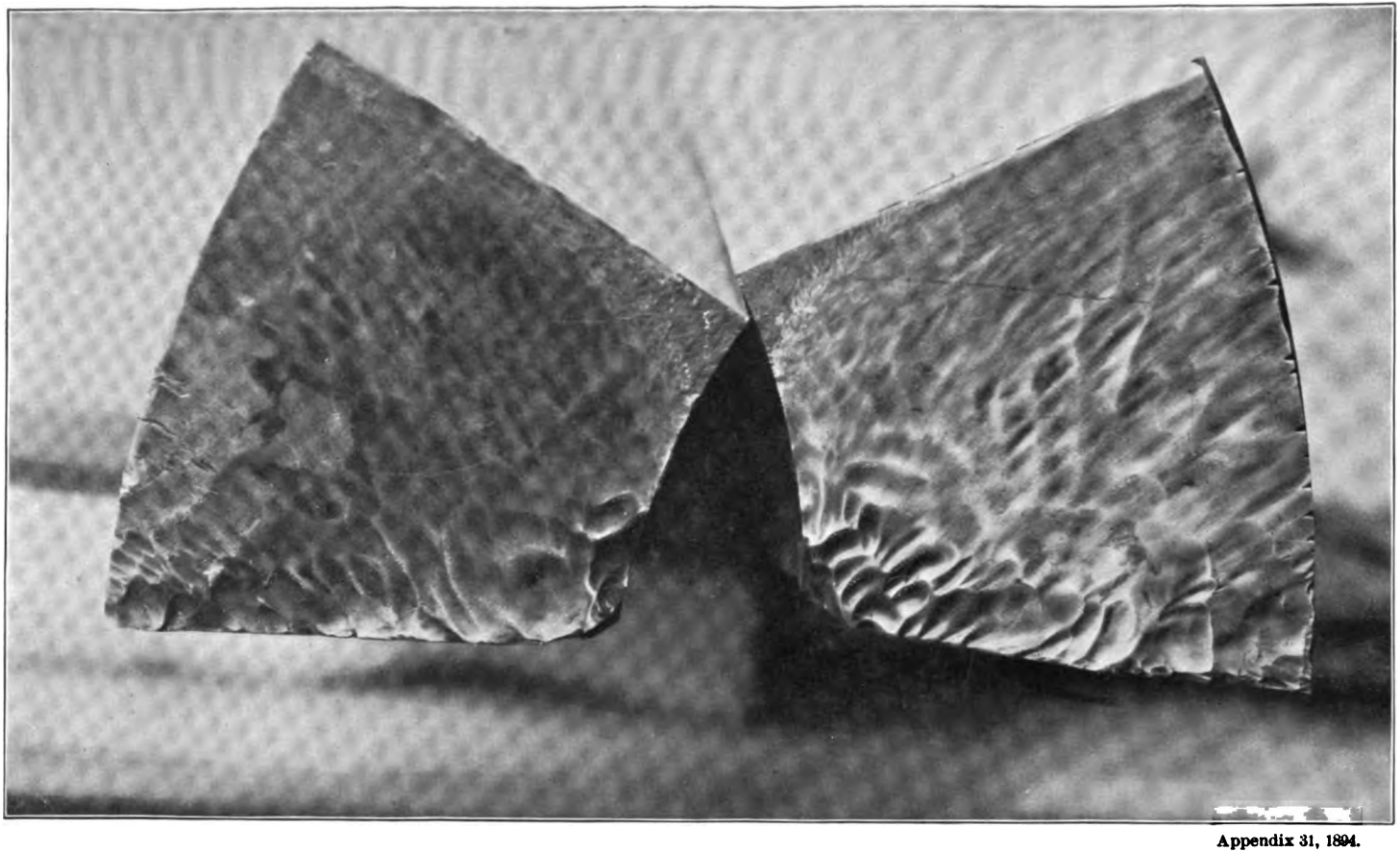

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APPENDIX 32.

TESTS OF A BATTERY OF PNEUMATIC DYNAMITE GUNS AT SANDY HOOK.

(6 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, October 3, 1894.

SIR: In compliance with your instructions of March 26, 1894, directing the board to "conduct and report with conclusions the tests required for acceptance of the battery of pneumatic dynamite guns to be erected by the Pneumatic Torpedo and Construction Company, at Sandy Hook, N. J., under its contract of January 27, 1893," it has the honor to submit the following:

The battery consists of two 15-inch guns, model 1890, and an 8-inch gun, with the necessary boilers, air compressors, reservoirs, and electric motors.

A detailed description of these guns and accessories is given in the Report of the Chief of Ordnance for 1890, page 364. The description therein given by Lieut. Col. J. P. Farley, Ordnance Department, applies to the present battery, except in the following particulars, which have been, with the drawings, furnished by the Pneumatic Torpedo and Construction Company.

THE 8-INCH GUN.

The hydraulic ram for elevating and the hydraulic motor for traversing have both been replaced by electric motors, located within the gun-carriage frame. One electric motor for traversing is connected by suitable gears to a pinion on a vertical shaft at the front of the carriage, which engages in a circular rack bolted to the foundation.

The other electric motor is geared to a winding drum, on which is wound a wire rope that elevates the gun. The wire rope is attached to the heel of the truss which supports the barrel. The electric motors are of the "Lundell" type series, wound for 125 to 130 volts. They are nominally rated at five-horse power.

The electric current is directed to either of the motors by a switch located in an iron box near the breech of the gun. The speed of the motors is governed by a rheostat located under the loading platform and the motors are started, stopped, and reversed by a controller, also under the platform. The controller is moved by a handwheel within easy reach of the gunner when he sights the gun.

The weight of the truss and barrel have been balanced by a counterweight hung in a pit directly under the pintle of the carriage. The

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counterweight is supported by wire ropes attached to the same winding drum that serves for elevating. Crank handles are placed on both sides of the carriage for traversing and elevating by hand power.

Live rollers have been placed in the wheels of the carriage in order to reduce the friction. These roller bearings consist of 11 steel rollers § inch in diameter, 5 inches long, held in a bronze cage. Each roller is separated from its neighbor by a bronze bar to prevent their grinding upon each other.

Dust-proof washers are placed at each end of each wheel to prevent sand or dirt getting into the rollers. Similar roller bearings have been put in the wheels of the 15-inch gun carriages.

A new interlocking mechanism has been placed on the breech of the 8-inch gun to interlock the firing lever and valve mechanism with the breech gate in order to prevent the possibility of discharging the gun when the breech is open. The firing handle moves a horizontal shaft placed above and at right angles with the axis of the barrel. On this shaft, bearing against the end of the left trunnion, is a cast-iron sector keyed to the shaft and moved with the firing handle. A 1-inch steel bolt moves through a hole drilled diagonally in the left trunnion. One end of this bolt protrudes out of the center of the left trunnion; the other enters a hole in the breech gate. This bolt has a longitudinal movement. When in the extreme right position it locks the breech gate. When in the extreme left position it locks the firing handle and valve mechanism by intercepting the motion of the sector at the end of the left trunnion. In any intermediate position both the breech gate and firing mechanism are locked; on one side of this sliding bolt is a rack, and into this rack meshes a small pinion which is secured to the end of the small vertical shaft which extends up through the top of the breech casting. On the top of this vertical shaft is a second pinion inclosed in a bronze box to protect it from dirt and to serve as a guide for a second sliding rack which meshes with the pinion. The hinge pin of the breech gate, which stands in a vertical position when the gun is not elevated, protrudes out of the top of the breech casting, and has on the top end of it a fork holding a handle by which the breech is opened and closed. This handle has two motions, one in a horizontal plane to open and close the breech, the other in a vertical plane to move the bolt which does the interlocking. The horizontal motion is through an arc of about 95 degrees and the vertical motion about the same. The movement of the handle is guided by a slot in a brass box which covers the top of the breech-hinge-pin and incloses the mechanism. By raising the handle in a vertical plane, motion is given to sliding bar by a lug attached to the handle engaging in a notch in the sliding bar. A rack is cut on the side of the bar to engage with a pinion on a short vertical shaft. Another small pinion is secured to the lower end of this shaft, which in turn transmits the motion to a second sliding bar, extending across the top of the breech to the vertical shaft which moves the interlocking bolt, as explained above. Thus by means of two sliding bars with racks, four pinions and two vertical shafts, the motion of the handle is transmitted to the interlocking bolt.

A reverse motion of the handle first in a vertical plane unlocks the breech gate and locks the firing mechanism, and then further movement in a horizontal plane opens the breech. By this means all of the movements of opening and closing the breech and interlocking the same with the firing mechanism are accomplished by the movement of a single handle located within easy reach on the top of the breech casting. The interlocking is absolutely positive and thus making it impossible for an accident to happen—which it was designed to prevent.

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The accompanying drawings of this breech interlocking mechanism will aid in making clear its method of working, Plates I and II.

THE 15-INCH GUN.

The hydraulic power for handling the guns has been replaced by electric power. One electric motor serves to both traverse and elevate the piece. Two friction clutches are placed on horizontal shafts, and so arranged that they can be operated by a horizontal handle within reach of the gunner, who stands on a platform on the left side of the carriage. When this lever is in one extreme position, one of the friction clutches is thrown into gear with the elevating worm. When the handle is in the other extreme position, the second friction clutch is thrown into gear with the traversing worm and the first clutch is thrown out of gear. In the middle position of the handle both clutches are thrown out of gear. The elevating worm engages with a rack sector attached to the gun and thus elevates the gun.

The traversing worm engages with a worm wheel keyed to the top of a vertical shaft, having a pinion on its lower end engaging with the circular rack on the interior of the bed plate.

The electric motor is of the drum type of armature, revolving between four pole pieces. It is a slow-speed, series-wound machine, controlled by a rheostat placed underneath the platform at the left of the carriage. More or less resistance is thrown in or out of the circuit, and the motor is reversed by a hand wheel attached to a vertical shaft extending out of the controller box placed underneath the platform. The current to the electric motors in all the gun carriages is supplied by a dynamo, built by the Easton Electric Company, located within the engine house and driven by a high-speed New York safety steam-power engine. The current supplied usually has an electro-motive force of 130 volts, the strength of the current depending upon the speed with which the motors are running, conditions of starting and stopping, etc. The current is conveyed to the motors in the gun carriage by insulated cables which pass up through the pintle of the carriage, a suitable swinging joint having been provided to permit the gun to be traversed through 360° without breaking the continuity of the circuit.

The method described by Col. Farley of bringing projectiles from the magazine and placing them on the loading carriage is not the same as that now used at Sandy Hook. Instead of a railway track of which he speaks, trucks have been used to wheel the projectile in its loading tray from the magazine, the trays being run off the trucks onto the loading carriage when two are brought in line. The track might easily be substituted for the trucks.

THE AIR COMPRESSORS.

The air compressors used at Sandy Hook were built by the Rand Drill Company. They are duplex, having two high-pressure steam cylinders with connecting rods attached to cranks on opposite ends of the shaft, at 90 degrees from each other, with a heavy fly wheel between them.

The engines are of the "girder" type, with the "Meyers automatic cut-off valve gear." The air cylinders are four in number, two being placed in line with each steam cylinder, one piston rod extending through the steam cylinder and air cylinders. There are three stages of compression which take place in two low-pressure cylinders, one

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intermediate and one high-pressure cylinder. The low-pressure cylinders have pistons packed with the ordinary metallic rings, but are single acting, one end of each cylinder having been left open. The air is compressed in these cylinders to about 75 pounds per square inch. From these it passes to an intercooler, which consists of a series of copper pipes surrounded by water. The outer casings of the intercoolers are of cast iron. They are cylindrical in form and located in a horizontal position just above the air cylinders. The air passes from the first intercooler to the intermediate cylinder, where it receives its second compression to about 425 pounds per square inch. From this cylinder it passes to a second intercooler, which is similar in every respect to the first. From the second intercooler it flows to the high-pressure cylinder, where it receives its final compression, varying from 425 pounds to 2,000, according to the conditions under which the machine is running. After leaving the compressor the air passes through a cooler located underneath the floor and consisting of ten coils of $\frac{5}{8}$-inch copper pipe connected in parallel to suitable bronze manifolds and submerged in a tank of water. When the air leaves this cooler it has a temperature slightly above that of the atmosphere. From this cooler the air flows to the reservoirs in the building or to the gun. All of the air cylinders are water-jacketed. All of the air-cylinder valves, both intake and outlet, are of the "poppet" type, with springs to close them. Water for the air-cylinder jackets, intercoolers, and after-coolers is supplied by 2 small Worthington duplex pumps, each capable of supplying about 180 gallons per minute. Each air compressor is designed to supply 350 cubic feet of air at 1,000 pounds pressure per square inch when running at 125 revolutions per minute.

The following are some of the more important dimensions and a brief description of the parts of the compressors in detail:

ENGINE.

There are two steam cylinders, each 16 inches diameter by 22 inches stroke, with Corliss frames having a foot under the end of the guide.

Cross heads and guides.—The crosshead guides are bored in line with the cylinders, and at the same setting the cylinder flanges are turned to secure alignment. The cross-head gibs are of composition adjustable by set screws to take up wear. No babbit is used in any bearing about the machine.

Main bearings.—The main bearings are in four parts, with wedge adjustment for taking up wear. The wearing surfaces are of composition except the top piece which is cast iron. The bottom pieces are fitted with self-adjusting rocking device to secure accurate bedding. A large opening is cast through the pillow-block cap and top pieces of bearings to allow inspection of the shaft while in motion, and flooding if necessary. The openings are closed by removable caps fitted with automatic sight-feed lubricators.

Steam cylinders and pistons.—The pistons are fitted with a follower, and spring set rings arranged to carry their share of the weight of the piston. The piston rods are of steel. The cylinders are felted and lagged with walnut.

Steam valve gear.—The steam cylinders are fitted with "Meyers' adjustable cut-off valves," adjustable by a handwheel when the engine is in motion, and the point of the cut-off is indicated by a moving pointer, allowing the compressor to be run with wide-open throttle entirely under control of the cut-off valve.

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Air cylinders and pistons.—The air is compressed in three stages, but to equalize the work between the two engines the first stage is done in two cylinders, single-acting and arranged one on each side of the machine. The low-pressure cylinders are fitted with single-acting pistons; the intermediate and high-pressure cylinders with plungers driven directly by the low-pressure pistons. The intermediate and high-pressure cylinders have their plungers packed by means of stuffing boxes, soft packing being used in the former and metallic rings in the latter. The low-pressure cylinder is 14 inches in diameter, intermediate $8\frac{1}{2}$ inches, and the high-pressure $4\frac{1}{4}$ inches. All of the air cylinders are water-jacketed.

Intercoolers.—The intercoolers have 90 square feet of cooling surface each, composed of brass tubes. The intercoolers are made upon the double-pipe system, obviating all strains due to expansion and contraction.

Governor.—Each engine is provided with a speed governor to prevent racing. The governors are of the ordinary "ball" type, controlling the speed by throttling.

Fly wheel.—Fly wheels are made in halves and weigh about 6,400 pounds:

BOILERS.

Instead of 6 boilers mentioned in Col. Farley's report, 4 have been supplied. Two were built by the Biglow Boiler Company and correspond with Col. Farley's description. The other 2 boilers were built by the Ames Iron Company and are of the following dimensions and description:

Diameter of shell ..... inches..	66	Thickness of head ..... inch..	$\frac{1}{16}$
Length of shell ..... feet..	16	Number of tubes	98
Diameter of dome ..... inches..	36	Diameter of tubes ..... inches..	3
Height of dome ..... do....	40	Length of tubes ..... feet..	16
Thickness of shell ..... inch..	$\frac{3}{8}$		

The shells, heads, and domes of the boilers are of the best flanged steel, having a tensile strength of 60,000 pounds per square inch of section. Tubes are the best American-make charcoal iron, lapwelded. Braces are of best refined iron. All rivets equal to Burden's best brand.

Construction.—The shells of the boilers are constructed with one plate on the bottom and one plate on the top. There are no seams on the bottom of the boilers except at the head. Horizontal seams and the dome seams are double-staggered riveted; other seams single-riveted. Heads and domes are braced to the shells of the boilers with solid crowfoot braces riveted at each end. There is a manhole in the top of each shell back of the dome, and a manhole in the front head under the tubes. The boilers are supported on the masonry by two cast-iron brackets riveted to each side of the shell. The tubes are set in straight, horizontal, and vertical rows about 1 inch apart each way. There is a smoke box at the front end of each boiler. Each boiler has an arch front, with flue door and frame of cast iron bolted to the smoke box; double flue, fire and ash pit doors. The fire doors are provided with liners and necessary mouthpieces for supporting brick around the opening. There is a door at the back.

The grates are 66 inches wide and 60 inches long, with the necessary bearing bars.

The two boilers are furnished with six buck stays for supporting the side walls, with rods extending crosswise of the setting. The two boilers are set in battery.

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Fittings and fixtures.—Each boiler is supplied with one steam gauge, one lever safety valve, one water gauge fitted with standpipe 3¾-inch gauge cocks, and 2-inch blow-off cock, 1½-inch check-feed valve. Each boiler has a stack 30 inches in diameter and about 60 feet high, made of No. 14 iron, with a suitable damper in each stack.

Masonry.—The outside walls are 24 inches thick, center wall 30 inches thick, rear wall 20 inches thick, bridge wall 24 inches thick. The side and center walls are carried up above the supporting brackets and carefully safed into the boilers.

The furnace from the front to the rear of the bridge wall and the top of the rear arch are lined with fire brick laid in fire clay. The balance of the setting is of hard-burned brick laid in lime and cement mortar.

The engine and boiler house is 100 feet long, instead of 80, as stated in Col. Farley's report.

PROJECTILES.

The projectiles furnished are the same as described in Col. Farley's report, except that the tail tubes of the 15-inch full-caliber projectiles have been made 7⅝ inches diameter instead of 4 inches, and the wings are 10 inches long with a gas check in rear similar to the gas checks used with the subcaliber projectiles.

The heads of all of the projectiles have been adapted to the new trigger fuse, as described in connection with the fuse.

The guiding and rotating wings of the 6-inch subcaliber projectiles for the 8-inch gun have been made exactly the same as the wings of the 8-inch full caliber projectile for the same gun, shown on Plate III.

THE FUSE.

[Plate IV.]

The fuse, known as a trigger fuse, is inserted at the point of the projectile, after removing a cap that covers the fuse cavity. The fuse body is 3⅜ inches diameter, and 11⅜ inches long from the end of the detonator to top of the handle. There is a narrow flange upon the front end, 4 inches in diameter, which forms a bearing to support the fuse in the projectile.

A handle screwed into the outer end serves as a cover, as well as affording means of getting hold of the fuse for insertion and removal. A brass case 12⅜ inches long and 3 inches in diameter is screwed to the inner end of the fuse and contains 2¾ pounds of dry gun cotton for a priming charge.

A detonator, consisting of a small copper cylinder 1¼ inches long, three-eighths inch diameter, containing 37 grains of fulminate of mercury, is held by a brass washer to the inner end of the fuse and extends into the dry gun cotton charge. These detonators were made at the torpedo station, Newport, R. I., and are the same as used in the Whitehead torpedoes. The washer holding the detonator is clamped by a brass gland between a vulcanite disk and ring to deaden any vibration. Fire is communicated to the fulminate through a small hole in the center of the washer, this hole being normally covered by a thin piece of shellaced paper.

The head of the projectile plays an important part in the action of the fuse. It is made of cast bronze, ogival in form, and one-fourth inch thick. On the inside of the head is a bronze casting, called the hammer sleeve, secured to the head by a screw thread. The hammer sleeve contains the fuse and supports eight radial hammers which

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stand at an angle of 60° with the axis of the projectile and are pressed against the interior surface of the head by spiral springs surrounding each hammer.

The head is made thin in order that it shall crush in or collapse in case the projectile should strike a solid object, such as the side or deck of a ship. The end of the hammer sleeve extending into the point of the head, against which the flange of the fuse bears, is made quite thin, and lantern holes are cut in it in order that it may collapse with any blow that crushes the head. A copper protecting case screws into the hammer sleeve rearward and surrounds the dry gun-cotton primer. It holds the explosive charge of the projectile in place when the fuse and primer are removed.

The fuse has three distinct means of exploding the detonator:

First. Means of exploding a short time after striking a slight resisting medium, such as water or loose sand.

This is accomplished by two spring-actuated hammers which strike caps and start time trains burning when the hammers are released by the movement of the trigger upon impact of the shell.

The two spiral springs which move the hammers are located in two circular cavities in the center of the fuse. They have a force of 90 pounds, and press against circular piston guides that in turn press against the heels of two hammers. These hammers turn about a common pivot like the blades of a pair of shears.

The hammers strike two caps located on opposite sides in the interior of the fuse, held on nipples which screw in from the outside. These nipples have holes drilled through them which communicate with channels containing slow-burning powder composition. The powder composition is pressed into a brass tube having a length to give the desired delay, and this tube fits tightly into the channels, which are three-sixteenths-inch diameter holes drilled in the body of the fuse parallel with its axis. From the time train fire is communicated to the detonator by a flash charge of flocculent dry gun cotton and of quick-burning rifle powder, these fill the two chambers, respectively, between the detonator and the ends of the time trains.

Normally the two hammers are held from striking the caps by their ends entering a cavity in the face of a circular truncated metal piece, termed the trigger. The trigger rests against a narrow circular seat and is held in place by a conical spiral spring. Until the fuse is fired from a gun the trigger is positively locked in place by four steel balls. When the balls are removed the trigger is free to move forward and trip the hammers when the projectile is retarded sufficiently to cause the inertia of the trigger to overcome the force of the conical spring holding it in place, as, for example, when the projectile enters the water. By making this spring strong or weak the sensitiveness of the fuse can be adjusted within desired limits. The energy required to fire the caps is stored up in two compressed springs and the trigger has only to release this energy. In many earlier forms of fuses the blow of a ball or plunger similar to this trigger was used to fire the caps, and with heavy projectiles and a necessarily light ball a very considerable retardation of the projectile was required (such as could not be gotten by projectiles striking the water with a very low velocity) to fire the cap. This is the most novel feature of this fuse. Because it can be made so extremely sensitive, however, it does not follow that it need be so, for by simply making the trigger spring very stiff it becomes very insensitive. Furthermore, it does not follow that because the fuse is sensitive that it is dangerous to handle. Under all conditions of handling the trigger

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is positively locked, making it perfectly safe. Another feature of this hammer and trigger arrangement is the fact that it will operate no matter how the projectile strikes, even if it falls flat on its side. This is due to the fact that the center of gravity of the trigger is far in advance of its seat, and that the chamber in which it is contained is large enough to permit of sufficient side movement to trip the hammers.

Second. Method of explosion upon striking point-blank against a solid, unyielding object:

The body of the fuse is made thinner and weaker in a section between the detonator and the time trains, and in this space a steel nipple is placed carrying a cap. In case the projectile should strike point-on against some solid object like the side armor of a man-of-war, the head of the projectile will collapse and in turn collapse the fuse at this weak section, firing the cap which communicates directly by a flash channel with the fulminate detonator, thus causing instantaneous explosion. The time trains would be ignited at the same time but the projectile would explode before they could burn out.

Third. Method of explosion upon striking a glancing blow:

In line with the eight hammers held in the hammer sleeve and arranged about the outside of the fuse are eight firing pins covering caps. Flash channels lead from each of these caps directly to the fulminate detonator. In case the projectile should strike a glancing blow against the side of a ship, inclined armor, or any rigid body, the hammers will be driven against the firing pins either by the crushing of the head or by rebounding from the interior of the head, causing instantaneous explosion. The springs under the hammers are made sufficiently stiff to prevent the hammers from striking the firing pins and causing an instantaneous explosion when the projectile strikes a glancing blow on the water—they require the more severe blow of striking a rigid body to make them act.

In order to make the fuse safe in handling, and while it is in the bore of the gun, a sleeve fits the outside of the fuse body and has a limited motion parallel with its axis. To prevent its revolving around the fuse the point of a screw guides it by running in a slot. There are eight holes in this sleeve corresponding with the eight side hammers, and four holes corresponding with the four balls that lock the trigger. Within this sleeve is a second shorter sleeve and a stiff spiral spring between shoulders of both sleeves tending to separate them. Before the projectile containing the fuse is discharged from the gun the two sleeves are secured together by two double pins with a joint in each. The sleeves are fastened to the body of the fuse by two small shearing screws. Before firing the long sleeve is in a position to cover the eight firing pins, making it impossible for the side hammers to strike them, and in position to hold the four balls in place that lock the trigger. When the projectile is accelerated along the bore, both sleeves, after breaking the two shearing screws, move rearward against a babbitt seat. This rearward motion is about three-eighths inch, and it causes the two jointed pins that have secured the two sleeves together to be pushed outward by sliding up an inclined surface until the joint in the pins coincides with the joint between the two sleeves, thus releasing all connection between the two sleeves. So long as the projectile is being accelerated in the bore the sleeves remain in their rear position, but when the acceleration ceases, as the projectile leaves the muzzle, the outer sleeve moves forward by the force of the spiral spring acting against a shoulder within it. Its motion is somewhat retarded by an air dashpot into which its front edge enters. It finally comes to

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rest in its forward position when the projectile has gotten well away from the gun. In this position the eight firing pins are uncovered to the side hammers and the four balls that lock the trigger are free to drop or be thrown out by the centrifugal force of the revolving projectile, thus unlocking the trigger.

In order to give additional safety in handling the fuse before it is inserted into the projectile, a screw, with a large milled head, is put through both protecting sleeves into the body of the fuse, and two long pins, also having large milled heads, are put through the fuse in a position to hold the hammers from striking the caps when the trigger is removed. The heads of this screw and of two long pins are so large that they must be removed before it is possible to enter the fuse into the projectile, thus making it impossible to leave them in the fuse by mistake.

The fuses are packed in hermetically sealed tin cases and six placed in a wooden box lined with felt. A box of tools is supplied for charging, testing, and assembling the fuses.

For 6-inch projectiles smaller fuses are used, similar in every respect to the one just described except that the side hammers are omitted. (*See* Plate III). In projectiles of this size there is hardly room for them, and there is less need of them because the ogival head is so small and short.

For details of manufacture, attention is invited to report of Capt. W. B. Gordon, Ordnance Department, of June 25, 1894, who was charged with the inspection of material and supervision of erection of the battery.

On the 20th of June the board was notified by the Pneumatic Torpedo and Construction Company that the plant of three guns, with boilers, air compressors, and all accessories, would be completed (according to the terms of its contract dated January 27, 1893) and ready for inspection and test, June 21. In reply, the company was notified that the board would be ready on the 26th of June to commence the test, and a copy of the approved programme was inclosed.

The afternoon of the first day was devoted to an examination of the plant, and to traversing and elevating the guns.

The following day, while the company was making some tests of its own, three sections of pipe, or about 30 feet in length, burst with a loud report. The pipe, which was 2½ inches in diameter and one-half inch thick, was literally turned inside out. The front of the building near the broken pipe was blown out, and fragments of pipe and of the manifold were thrown dangerously near five men employed in and about the building—all escaped miraculously. The gauges indicated a pressure in the pipes of only 1,300 pounds per square inch. No satisfactory reason for this explosion has been given.

Before the repairs necessitated by this accident were completed, and while the company was making some tests with the 8-inch gun, the breechblock was blown violently backward and broken. The accident was due to inadvertence on the part of the superintendent in not closing and locking the block before firing. In repairing this damage it was necessary to make a new block, and in doing this a locking arrangement was designed and applied which will prevent the possibility of a recurrence of this danger. This new interlocking mechanism is described in the changes made in the 8-inch gun, and is shown on Plates I and II.

All the repairs having been made, the board recommenced, August 17 the tests which have been carried on whenever the weather and

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other circumstances permitted. The following programme is the one finally approved by you, and which has been followed, except in two instances, which will be referred to later:

PROGRAMME.

(1) The Secretary of the Treasury to be requested to have the boilers inspected by the United States local inspectors of steam vessels.
(2) Note to be made of the time required to traverse the gun through 360 degrees of arc by power and by hand, and the number of men necessary.
(3) Note to be made of the time required to elevate the gun the extreme amount permitted by the mounting by power and by hand, and the number of men necessary.
(4) Examination to be made of the valve and firing device and the drawings thereof, and note made of the means of opening and closing and of controlling the loss of air.
(5) Examination to be made of the shell and drawings thereof, and note made of the features of the construction for insuring steady flight and strength to resist breaking up in the air or on impact with water, and for insuring safety in loading and firing.
(6) Examination to be made of the fuse and drawings thereof and note made of the provisions for insuring safety in handling, certainty of action on impact, explosion of the first order, delay action after entering water in time.

FIRINGS.

(7) Note to be made of the loss of pressure in the firing reservoir at each round.

WITH THE 8-INCH GUN.

(8) One round with 50-pound charged shell, the fuse set for impact, for range of 100 yards or less.
(9) One round with 50-pound charged shell, with fuse set for impact, to be fired for extreme range.
(10) Three rounds with 50-pound charged shell, with fuses set for delay action, to be fired at any range convenient for observing the action of the fuses.
(11) Five rounds with 100-pound charged shell, with fuses set for impact, for accuracy at 2,600 yards range.

WITH ONE 15-INCH GUN.

(12) One round with 50-pound charged shell, the fuse set for impact, for range of 100 yards or less.
(13) Two rounds of 50-pound charged shell, the fuses set for impact, to be fired for extreme range.
(14) Two rounds with 100-pound charged shell, the fuses set for impact, at each of the ranges 1,000, 2,000, and 3,000 yards, and extreme.
(15) One round with 200-pound charged shell, the fuses set for impact, at each of the ranges 1,500 yards and extreme.
(16) Eight rounds with 200-pound charged shell, the fuses set for delay action, for accuracy at 3,500 yards range.
(17) Five rounds with 500-pound charged shell, the fuses set for delay action, for accuracy at 2,000 yards range.
(18) Five rounds with dummy projectiles, representing 100-pound charges, to be fired as rapidly as possible and the time noted for firing the first round and for firing the five rounds.
(19) Ten rounds with dummy projectiles, representing 200-pound charges, to be fired as rapidly as possible, and the time noted for firing the first round and for firing the 10 rounds.
(20) Ten rounds with dummy projectiles representing 500-pound charges, to be fired as rapidly as possible, and the time noted for firing the first round and for firing the 10 rounds.

WITH THE SECOND 15-INCH GUN.

(21) One round with 500-pound charge, with the fuse set for impact.
(22) Five rounds with dummy projectiles, representing 500-pound charges, to be fired as rapidly as possible, and the time noted.
(23) The entire battery to be worked continuously for three hours, 20 rounds being fired from the 8-inch and 15 each from the two 15-inch guns during the first hour,

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and the guns to be fired as rapidly as possible during the remaining two hours, in the ratio of 4 rounds from the 8-inch gun and 3 each from the 15-inch guns. These rounds to be "air shots," that is, without projectiles, the determined amount of air being released for each round.

RESULTS.

(1) By direction of the Secretary of the Treasury an assistant inspector tested the boilers to 135 pounds hydrostatic pressure. He reported them perfectly tight, and safe to carry 90 pounds per square inch.

(2) The guns were traversed through 360 degrees, as follows:

By hand.

The 8-inch in 5 minutes 56 seconds; 6 men at the handles. Fifteen-inch No. 1 in 9 minutes 11 seconds; 16 men working, 6 at a time. Fifteen-inch No. 2 in 7 minutes 11 seconds; 6 men at handles, 4 extra men for relays.

By electric power.

The 8-inch in 1 minute 25½ seconds. Fifteen-inch No. 1 in 42 seconds. Fifteen-inch No. 2 in 55½ seconds.

(3) The times for elevating and depressing the guns were:

By hand power.

For the 8-inch, elevated from 0 degrees to 35 degrees 45 seconds; depressed from 35 degrees to 0 degrees in 48 seconds; employing 6 men. Fifteen-inch No. 1, elevated from 0 degrees to 34 degrees 30 minutes in 24 seconds; 4 men at handles. Depressed from 34 degrees 30 minutes to 0 degrees in 23⅞ seconds; 4 men at handles. Fifteen-inch No. 2, elevated from 0 degrees to 34 degrees 30 minutes in 29¼ seconds. Depressed from 34 degrees 30 minutes to 0 degrees in 29¾ seconds.

By electric power.

The 8-inch was elevated from 0 degrees to 35 degrees in 14 seconds. Depressed from 35 degrees to 0 degrees in 15 seconds. Fifteen-inch No. 1, elevated from 0 degrees to 34 degrees 30 minutes in 7⅞ seconds. Depressed from 34 degrees 30 minutes to 0 degrees in 8 seconds. Fifteen-inch No. 2, elevated from 0 degrees to 34 degrees 30 minutes in 9 seconds. Depressed from 34 degrees 30 minutes to 0 degrees in 11 seconds.

(4) Before and during the firings the valves, firing devices, and appliances for controlling the loss of air were examined and carefully watched. While they are complicated, each device seems to properly perform its part in the working of the general system.

(5) Shells of different calibers were examined, and all appeared to be sufficiently strong to resist breaking up in the air and on impact with water. During the firings no weakness of body was discovered. Every precaution seemed taken to insure safety in loading and firing.

During the firings the 15-inch full caliber projectiles and the 6-inch subcaliber shells for the 8-inch gun did not show a very smooth flight at times, but the targets made were, notwithstanding, very good.

The explosive composition is said to be 87 per cent nitroglycerin, 8 per cent gun cotton, 3 per cent camphor, 2 per cent carbonate of magnesia.

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(6) Safety in handling the fuse is insured by means of a screw shown in Plate III. The fuse is inserted in the shell at the gun, but this can not be done till the screw is removed. The firings showed that the provision for insuring action on impact was good, as there were but two failures of ignition of the fuses during the firings.

The board had no means of determining the order of the explosion, other than by the effect on the water. It appeared to be of the first order.

The delay action of the fuses was not altogether satisfactory, but this may be accounted for from the fact that all were originally made for a delay of 2 seconds. In removing powder from the time train to make it correspond to a delay of 1½ seconds, either too much was removed or the train so broken up as to produce an almost instantaneous action. In many instances, when set for 2 seconds delay, the time was 2½ seconds.

(7) The loss of pressure in the firing reservoir was especially noticed during the three hours continuous test. As the time occupied and the number of shots fired were greatly in excess of any possible demands of service, the plant, although hard worked, proved itself capable of fulfilling all probable requirements.

(8) The programme called for a 50-pound charged shell, but it was not considered safe to explode such a quantity of gelatin so near the shore. The object of this firing being to determine the action of the fuse set for impact with a low elevation of the gun, it was thought that a small quantity of powder would answer the purpose. The shell was weighted with sand and charged with 1¾ pounds of rifle powder. The range was 185 yards. The powder was ignited on impact.

(9) The range of this shell was 3,590 yards. Flight good. Exploded on impact.

(10) The ranges of these three rounds were 2,542, 1,993, and 1,680 yards.

The fuses were set for a delay of one-half, 1, and 1½ seconds. The action of the first two was practically instantaneous. For the last one a delay of one-fourth second was claimed.

(11) The ranges for these rounds were 2,618, 2,607, 2,583, lost, and 2,616 yards, making an excellent group of shots. The fourth shell did not explode; the others did, on impact, as desired.

(12) In view of the possible danger in firing 50 pounds gelatin so short a distance as 100 yards from shore, the board changed this part of the programme, substituting for the live projectile a dummy that would float after striking the water. A fuse set for impact was imbedded in its head and after firing was recovered. The fuse had exploded. The range was 185 yards.

(13) The first of these ranges was lost; the second was 5,763 yards. Fuses set for impact acted promptly. Flight, good.

(14) Gun set for 1,000 yards range; actual ranges were 832 and 874 yards. Action of fuses and flight good.

Gun set for 2,000 yards range; actual ranges were 2,058 and 1,816 yards. Action of fuses good; flight, fair.

Gun set for 3,000 yards range; actual ranges were 3,457 and 2,764 yards. Action of fuses good; flight, unsteady.

Gun set for extreme range; actual ranges were 5,021 and 2,136 yards. One fuse failed to explode. Flight of one shell bad, wings broken.

(15) Gun set for 1,500 yards range; 200-pound charged shell. Fuse set for impact. Range 2,097 yards. Action of fuse and flight of shell good.

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Gun set for extreme range; result, 4,059 yards. Action of fuse and flight of shell good.

(16) Eight 200-pound charged shell; fuses set for delay action for accuracy at 3,500 yards. Ranges 3,566, 3,560, 3,575, 3,553, 3,576, 3,543, 3,565, and 3,567 yards. Fuses set for 2 seconds' delay; exploded 2½ seconds; flight of shells good.

(17) Of the 5 rounds, with full caliber shell, the first 4 fuses were set for a 2 seconds' delay, the fifth for impact. Two of the first 4 fuses exploded on impact, the other 2 delayed 2½ seconds; the fifth exploded on impact. The flight of none of the shells was smooth; the target made was exceptionally good, however; the ranges were as follows: 1,940, 1,938, 1,878, 1,937, and 1,935 yards.

(18) Five dummy projectiles, representing 100-pound charges, were fired in 8 minutes and 45⅘ seconds; the first round taking 51⅔ seconds of time.

(19) The time occupied in firing 10 dummy projectiles, representing 200-pound charges, was 14 minutes 40 seconds; the first round was fired in 37 seconds.

(20) Ten dummy projectiles, representing 500-pound charges were fired, the first round in 52 seconds, the 10 in 15 minutes 36⅕ seconds. Average weight of shell, 1,160 pounds.

(21) The second 15-inch gun with 500-pound charged shell; fuse set for 2 seconds' delay; the range was 2,263 yards. The flight of projectile was good. The fuse did not act promptly, as the delay was 2⅗ seconds.

(22) The time occupied in firing 5 dummy projectiles, representing 500-pound charges, was 7 minutes 58 seconds.

(23) The results of this test at third trial have been tabulated to show the initial and final pressure of each shot; the corresponding air loss and valve setting.

Air shots—Continuous three-hour test for capacity and endurance of pneumatic gun plant at Sandy Hook, N. J., September 3, 1894.

FIRST HOUR.

[First round at 3:43 p. m., fiftieth shot at 4:29 p. m.]

	No. 1. 9-inch gun.					No. 2. Middle gun.					No. 3. North gun.			
	Initial pressure.	Final pressure.	Air loss.	Valve setting.		Initial pressure.	Final pressure.	Air loss.	Valve setting.		Initial pressure.	Final pressure.	Air loss.	Valve setting.
1	1,008	940	68	220	2	1,001	913	88	205	3	1,001	913	88	260
4	1,002	904	98	220	5	1,000	926	74	190	6	1,000	913	87	250
7	999	870	129	220	8	1,000	924	76	190	9	1,000	924	76	240
10	997	911	86	200	11	998	922	76	190	12	1,000	932	68	240
13	1,000	928	72	190	14	1,000	922	78	190	15	1,001	931	70	243
16	1,002	931	71	190	17	1,000	918	82	190	18	1,000	929	71	247
19	1,002	929	73	195	20	1,000	916	84	190	21	1,003	926	77	250
22	1,003	928	75	200	23	999	911	88	190	24	1,001	925	76	250
25	1,000	925	75	200	26	1,000	911	89	190	27	1,000	925	75	250
28	1,000	925	75	200	29	1,000	912	88	190	30	1,000	920	80	250
31	999	925	74	200	32	998	911	87	190	33	1,001	917	84	250
34	1,000	925	75	200	35	999	911	88	190	36	1,002	917	85	250
37	1,000	926	74	200	38	1,001	914	87	190	39	1,002	917	85	250
40	1,000	924	76	200	41	1,000	912	88	190	42	1,004	918	86	250
43	999	925	74	200	44	1,000	911	89	190	45	1,000	912	88	250
46	1,000	929	71	200										
47	1,002	928	74	200										
48	1,000	926	74	200										
49	1,000	924	76	200										
50	1,000	925	75	200										

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Air shots—Continuous three-hour test for capacity and endurance of pneumatic gun plant at Sandy Hook, N. J., September 3, 1894—Continued.

SECOND HOUR.

[First shot at 4:43 p. m., thirtieth shot at 5:34 p. m.]

	No. 1. 8 inch gun.					No. 2. Middle gun.					No. 3. North gun.			
	Initial pressure.	Final pressure.	Air loss.	Valve setting.		Initial pressure.	Final pressure.	Air loss.	Valve setting.		Initial pressure.	Final pressure.	Air loss.	Valve setting.
1	1,003	934	69	200	2	1,000	913	87	190	3	999	932	67	250
4	995	927	68	205	5	1,000	912	88	190	6	1,001	929	72	252
7	999	929	70	210	8	1,000	912	88	190	9	1,001	928	73	252
10	998	926	72	215	12	1,001	915	86	190	13	1,001	920	81	252
11	1,008	933	75	220	15	1,000	914	86	190	16	1,001	916	85	252
14	997	925	72	220	18	999	912	87	190	19	1,001	914	87	252
17	1,000	925	75	223	21	1,000	911	89	190	22	1,001	918	83	250
20	997	924	73	223	25	1,000	914	86	190	26	1,000	916	84	250
23	1,000	925	75	225	28	1,000	913	87	190	29	1,000	913	87	250
24	1,004	891	113	225	32	1,001	913	88	190	33	1,002	907	95	250
27	997	898	99	225										
30	1,000	900	100	225										
31	1,008	894	114	225										

THIRD HOUR.

[First shot at 5:43 p. m., thirtieth shot at 6:35 p. m; thirty-sixth round at 6:43 p. m.]

1	997	930	67	205	2	1,000	909	91	190	5	1,000	920	80	250
3	990	868	122	205	4	1,000	906	94	190	6	930	850	80	250
7	1,006	938	68	205	8	1,000	909	91	190	9	1,000	914	86	250
10	1,000	917	83	205	12	1,000	908	92	190	13	1,002	918	84	250
11	1,008	929	79	205	15	1,000	905	95	190	16	1,000	921	79	250
14	998	928	70	205	18	998	900	98	190	19	1,000	918	82	250
17	1,000	932	68	205	22	1,001	909	92	180	23	998	917	81	250
20	1,000	930	70	210	25	1,001	913	88	175	26	1,000	917	83	250
21	1,006	932	74	220	28	1,000	918	88	175	29	1,005	913	92	250
24	1,004	932	72	220	31	1,000	916	84	175	32	1,000	914	86	250
27	1,008	936	72	220	35	1,000	919	81	175	34	(?)	940	(?)	250
30	1,000	912	88	220										
33	1,000	930	70	220										
36	1,000	928	72	220										

In conclusion, the board finds that in most of the requirements the Pneumatic Torpedo and Construction Company has exceeded those called for by the contract, specifications, and programme. The flights of the full caliber shells for 15-inch guns and of some of the subcaliber projectiles were not as smooth as could be desired, but as the results in accuracy, as shown by the targets, were so good, the board does not consider this a cause for their rejection. The time occupied in traversing by hand the 15-inch gun should be improved upon.

The delay action of the fuses was not altogether satisfactory, but it is difficult to get an accurate measure of time at such long distances and for so short a period of time. There were but two failures to explode on impact of all so set.

There were many annoying delays during the tests, caused by breakages, which, though slight, for the time entirely disabled the guns.

It is believed by the board that these delays are inevitable, and must be expected in a system where any portion of a somewhat complicated series of pipes and valves is liable to be rendered unserviceable by the severe pressure to which they are subjected.

The breakage of the end of the stem of primary valve of gun No. 3 of the battery—a 15-inch gun—at seventh round, stopped all the firings for the day, and rendered it necessary to abandon for the time the effort to carry out the requirements of paragraph 23 of the programme. Again, the bursting of a small pipe on the 8-inch gun delayed for about three hours a second attempt at the same.

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The management of this battery can not be intrusted to ordinary soldiers, but skilled mechanics and electricians will be required to work and keep in order the guns and accessories.

During the three hours continuous test a favorable draft assisted the boilers materially, they were forced to their full capacity. Starting with a steam pressure of 95 pounds per square inch and air pressure of 2,000 pounds, at the end of the second hour the steam pressure was 70 pounds and air pressure 1,000 pounds per square inch; at the end of the third hour the pressures were 68 and 950 pounds, respectively.

A chart of the bay and harbor of New York is inclosed, showing the water covered by the 15-inch guns, at extreme ranges for the different charges of explosive. The extreme range for the 12-inch cast-iron mortar is also indicated.

Effects fully as great as could be produced by shells from these guns charged with 50 and 100 pounds of gelatin, could be obtained by shells charged with less sensitive high explosives which can now be fired from powder guns; and since the use of these guns would not be considered in cases when equivalent effects could be produced by the simpler and more generally useful powder guns, the 8-inch gun and the 15-inch gun as a projector of charges of 50 and 100 pounds should be thrown out of consideration in estimating the desirability of the system for coast defense. The 15-inch gun as a projector of charges of 200 to 500 pounds then assumes its proper place in the class of torpedo throwers, and upon its merits in such class it should be judged.

Examining the chart, it is seen that the 15-inch guns of the battery at Sandy Hook command, with 200-pound charges, the main channel for a distance of about 9,000 yards and the swash channel for about 4,200 yards. They would thus have under their fire, with these charges, a vessel running the main channel at the rate of 20 miles an hour for a period of 16 minutes, during which time each gun could discharge 10 projectiles; and would be able to reach a vessel running the swash channel at the same rate for a period of 7¼ minutes and fire at her 5 projectiles.

The 15-inch guns can not reach the swash channel with projectiles carrying charges of 500 pounds of explosive. They command the main channel with such projectiles for a distance of 4,300 yards, and would have under their fire a vessel as above for 7⅛ minutes, at which each gun could discharge 4 projectiles.

Although these figures would be much exceeded by similar ones for 8, 10, and 12 inch rifles and 12-inch mortars, they are far in excess of the possibilities with any other torpedo throwers or with any automatic torpedoes known to the board. For the purposes covered by such weapons their desirability seems to depend upon their certainty of readiness for action, the possibility and convenience of their safe instalment, and their cost.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(2790)

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Firing record dynamite gun

[Object of firing, accept

Date.	No. of firing.	Gun.	Kind of projectile.	Weight of charge.	Total weight.	Fuse setting.	Delay of explosion.	Elevation.
1894.				*Lbs.*	*Lbs.*			°
Aug. 16	1	North, or No. 3..	Sub 8-inch caliber, live.	104½	371½	Impact ...	Instantly ...	9
Aug. 16	2	North, or No. 3..	Sub 8-inch caliber, live.	104	371½	Impact ...	Instantly ...	9
Aug. 17	1	North, or No. 3..	Sub 6-inch caliber, live.	.....	301	Impact ...	Instantly ..	34½
Aug. 17	2	North, or No. 3..	Sub 6-inch caliber, live.	.....	304½	Impact ...	Instantly ...	34½
Aug. 17	3	North, or No. 3..	Sub 8-inch caliber, live.	104	370½	Impact	No explosion.	34½
Aug. 17	4	North, or No. 3..	Sub 8-inch caliber, live.	104	370	Impact ...	Instantly ...	34½
Aug. 17	5	North, or No. 3..	Sub 10-inch caliber, live.	213½	566½	Impact ...	Instantly ...	34½
Aug. 21	1	North, or No. 3..	Sub 6-inch caliber, live.	.....	305½	Impact ...	Instantly ...	34½
Aug. 21	2	North, or No. 3..	Sub 8-inch caliber, live.	104½	371½	Impact ...	Instantly ..	20
Aug. 21	3	North, or No. 3..	Sub 8-inch caliber, live.	104½	371½	Impact ...	Instantly ...	20
Aug. 21	4	North, or No. 3..	Sub 10-inch caliber, live.	212	565	Impact ...	Instantly ...	20
Aug. 21	5	Center, or No. 2..	Full 15-inch caliber, live.	515½	1,155½	2 seconds' delay.	2½ seconds...	34½
Aug. 22	1	North, or No. 3..	Sub 10-inch caliber, live.	212½	565½	2 seccnds' delay.	2½ seconds...	27
Aug. 22	2	North, or No. 3..	Sub 10-inch caliber, live.	214	571½	2 seconds' delay.	2½ seconds...	27
Aug. 22	3	North, or No. 3..	Sub 10-inch caliber, live.	215	566	2 seconds' delay.	2½ seconds...	27
Aug. 22	4	North, or No. 3..	Sub 10-inch caliber, live.	214	567	2 seconds' delay.	2½ seconds...	27
Aug. 22	5	North, or No. 3..	Sub 10-inch caliber, live.	213½	568½	2 seconds' delay.	2½ seconds...	27
Aug. 22	6	North, or No. 3..	Sub 10-inch caliber, live.	215	568	2 seconds' delay.	2½ seconds...	27
Aug. 22	7	North, or No. 3..	Sub 10-inch caliber, live.	214½	567½	2 seconds' delay.	2½ seconds...	27
Aug. 22	8	North, or No. 3..	Sub 10-inch caliber, live.	213½	566	2 seconds' delay.	2½ seconds...	27
Aug. 24	1	North, or No. 3..	Full 15-inch caliber, live.	505½	1,144½	2 seconds' delay.	2½ seconds...	34½
Aug. 24	2	North, or No. 3..	Full 15-inch caliber, live.	511½	1,146	2 seconds' delay.	Instantly ...	34½
Aug. 24	3	North, or No. 3..	Full 15-inch caliber, live.	515½	1,152½	2 seconds' delay.	2½ seconds...	34½
Aug. 24	4	North, or No. 3..	Full 15-inch caliber, live.	503½	1,151½	2 seconds' delay.	Instantly ...	34½
Aug. 24	5	North, or No. 3..	Full 15-inch caliber, live.	525½	1,157	Impact ...	Instantly ...	34½
Aug. 24	6	North, or No. 3..	Sub 8-inch caliber, live.	104	367½	Impact ...	Instantly ...	20
Aug. 31	1	North, or No. 3..	Floating projectile to test fuse.	.....	.....	Impact ...	Instantly ...	0
Sept. 6	1	8-inch gun, or No. 1.	Full 8-inch caliber, live.	.....	.....	Impact ...	Instantly ...	35½
Sept. 6	2	8-inch gun, or No. 1.	Full 8-inch caliber, live.	110½	302	Impact ...	Instantly ...	35½
Sept. 6	3	8-inch gun, or No. 1.	Full 8-inch caliber, live.	.....	.....	Impact ...	Instantly ...	35½
Sept. 6	4	8-inch gun, or No. 1.	Full 8-inch caliber, live.	109½	301½	Impact ...	No explosion	35½
Sept. 6	5	8-inch gun, or No. 1.	Full 8-inch caliber, live.	110	301	Impact ...	Instantly ...	35½
Sept. 6	6	North, or No. 3..	Sub 8-inch caliber, live.	104½	372½	Impact ...	Instantly ...	20
Sept. 10	1	8-inch gun, No. 1.	Sub 6-inch caliber, live.	53	197	Impact ...	Instantly ...	35½
Sept. 10	2	8-inch gun, No. 1.	Sub 6-inch caliber, live.	53½	197½	½ second delay.	Slight delay.	20
Sept. 10	3	8-inch gun, No. 1.	Sub 6-inch caliber, live.	53½	197	1 second delay.	Slight delay..	20
Sept. 10	4	8-inch gun, No. 1.	Sub 6-inch caliber, live.	53½	197½	1½ seconds' delay.	1.4 seconds ..	20
Sept. 10	5	8-inch gun, No. 1.	Sub 6-inch caliber, fuse test.	.....	.....	Impact ...	Instantly ...	0

*Flight good; slight gyration at first, then steadied down.

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battery at Sandy Hook, N. J.

ance test of battery.]

Initial pressure.	Loss of pressure.	Valve setting.	Range.	Time of flight.	Force of wind per second.	Direction of wind, o'clock.	Thermometer.	Barometer.	Humidity.	Remarks.
Lbs.	*Lbs.*			*"*	*Feet.*		° *F*			
1,000	30	0	832	.....	.....	.....	88	29.99	55	Flight good.
1,000	30	0	874	.....	.....	.....	88	29.99	56	Flight good.
1,000	193	430	Lost.	29	.....	.....	86	30.14	43	Flight good.
1,000	200	430	5,763	29.3	.....	.....	86	30.14	44	Flight good.
1,000	230	430	5,021	18.6	.....	.....	87	30.14	45	Flight good; did not explode.
1,000	235	430	3,175	26	.....	.....	87	30.14	47	Gyrated; wings broke.
1,000	230	430	4,059	23½	.....	.....	87	30.14	49	Flight good.
1,000	212	430	5,635	29½	.....	.....	76	30.12	58	Flight good; exhibition for Fortification Board.
1,000	32	0	2,058	.....	.....	.....	76	30.12	59	Flight good.
1,000	31	0	1,816	.....	.....	.....	76	30.12	59	Flight fair; slight gyration.
1,000	52	100	2,097	.....	.....	.....	77	30.12	57	Flight good.
1,000	212	350	2,278	.....	.....	.....	80	30.12	55	Flight good.
1,000	256	430	3,566	19½	6	9	83	30.22	46	Flight good.
1,000	258	430	3,560	.....	6	9	83	30.22	46	Flight good.
1,000	258	430	3,585	20	.....	.....	84	30.22	47	Flight good.
1,000	258	430	3,553	18¾	.....	.....	84	30.22	47	Flight good.
1,000	266	430	3,576	19	.....	.....	85	30.22	48	Flight good.
1,000	268	430	3,543	18½	.....	8	85	30.22	48	Flight good.
1,000	269	430	3,565	18¾	.....	.....	85	30.22	49	Flight good.
1,000	268	430	3,567	18¾	.....	.....	85	30.22	50	Flight good.
1,000	67	240	1,940	17	18.4	5	82	30.24	61	Flight fair; slight gyration.
1,000	67	240	1,938	17	12.5	5	82	30.24	62	Flight fair; wobbled toward end.
1,000	67	240	1,878	17	15.3	5	82	30.24	63	Flight fair; wobbled toward end.
1,000	68	240	1,937	17	16.3	5	82	30.24	64	Flight fair; wobbled toward end.
1,000	67	240	1,935	17	16.9	5	82	30.24	65	Flight fair; wobbled toward end.
1,000	80	225†	3,457	.....	About 15	5 to 6	82	30.24	66	Flight good; wobbled and straightened up.
1,000	30	0	185	.....	Slight breeze	.....	87	30.08	....	Fired at short range for testing action of fuse.
1,000	90	275	2,618	19	.....	.....	77	.....	....	Flight good.
1,000	74	275	2,607	19	.....	.....	77	.....	....	Flight good.
1,000	84	275	2,583	19.2	.....	.....	77	.....	....	Flight good.
1,000	84	275	Lost.	20	.....	.....	77	.....	....	Flight good; did not explode.
1,010	84	275	2,616	19.4	.....	.....	77	.....	....	Flight good.
1,000	74	225	2,764	15	.....	.....	77	.....	....	(*)
1,000	80	285	3,590	23	16.1	5	90	.....	....	Flight good.
1,000	82	285	2,542	15	16.5	5	89	.....	....	Flight good.
1,000	44	225	1,993	14	17	5	89	.....	....	Flight fair; slight gyration.
1,000	34	100	1,680	10.8	17.5	5	88	.....	....	Flight fair; slight gyration.
1,000	31	0	185	1	18	5	87	.....	....	(†)

†Flight good; regular live shell, weighted with sand; no gelatin, no fulminate detonator; loaded with 1¾ pounds black rifle powder.

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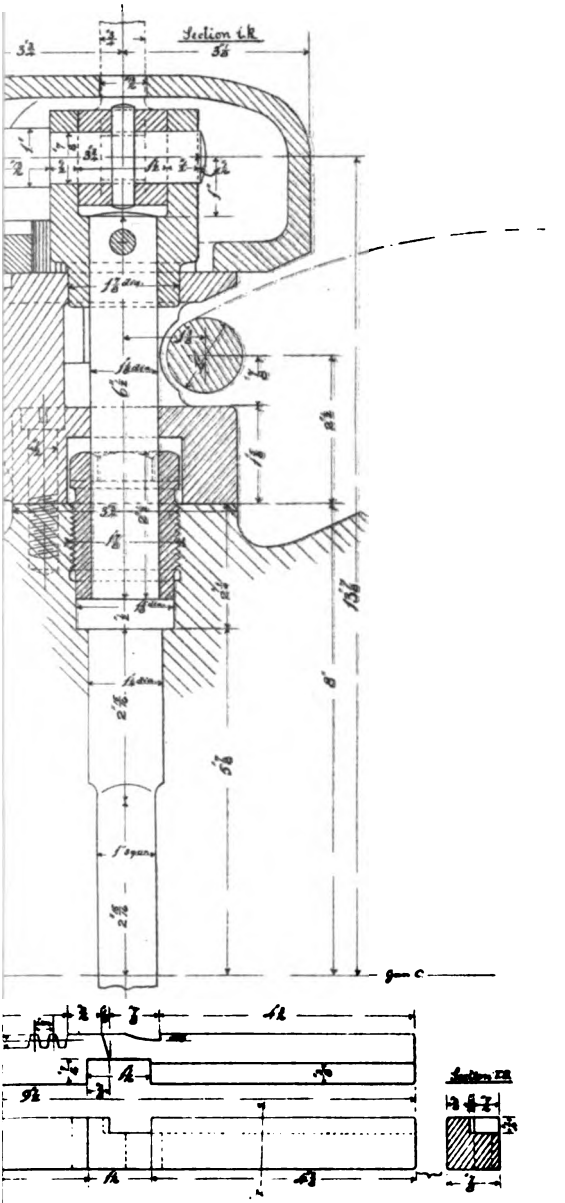

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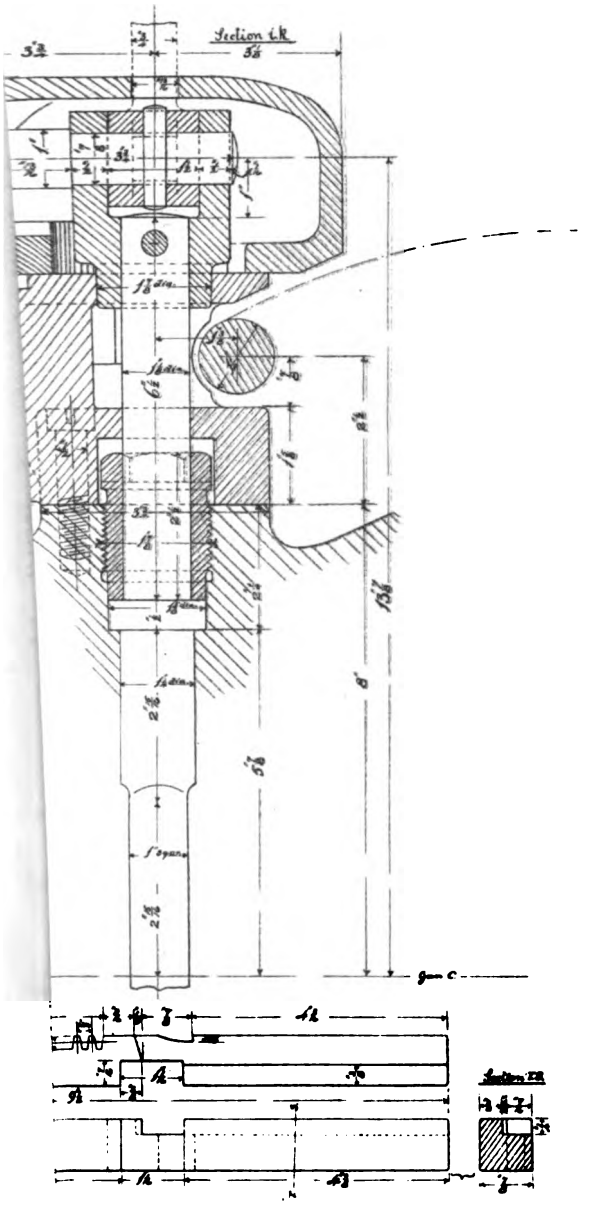

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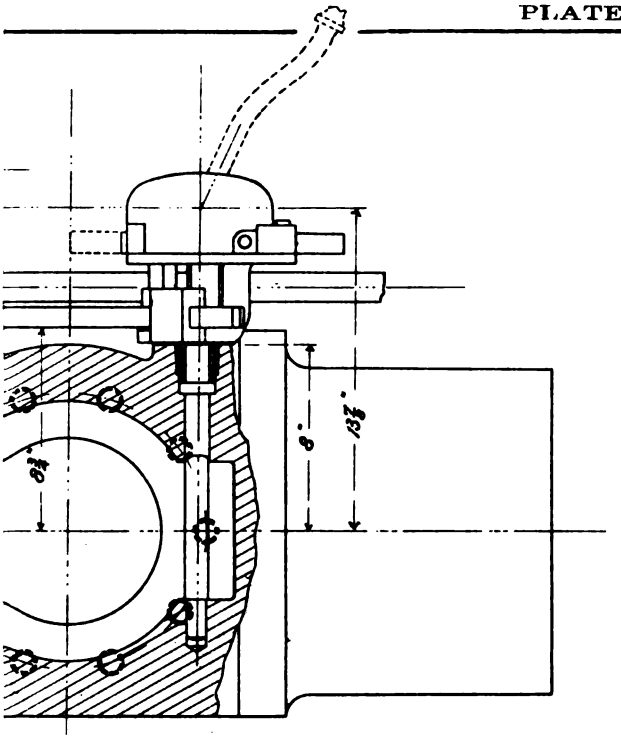

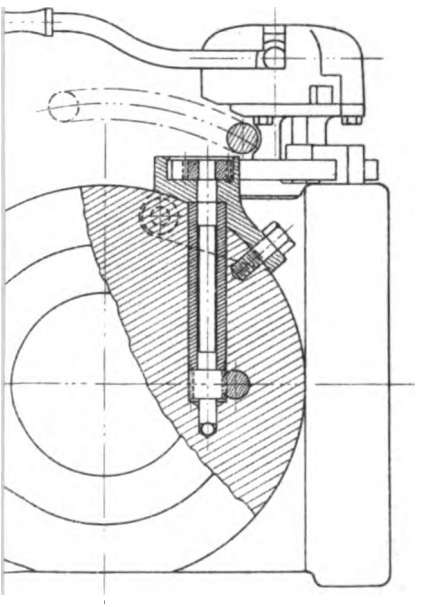

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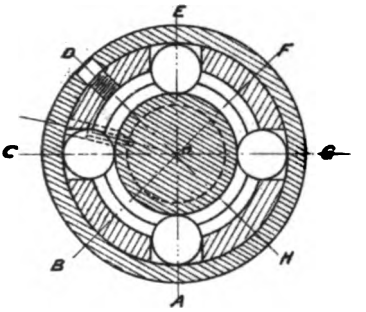

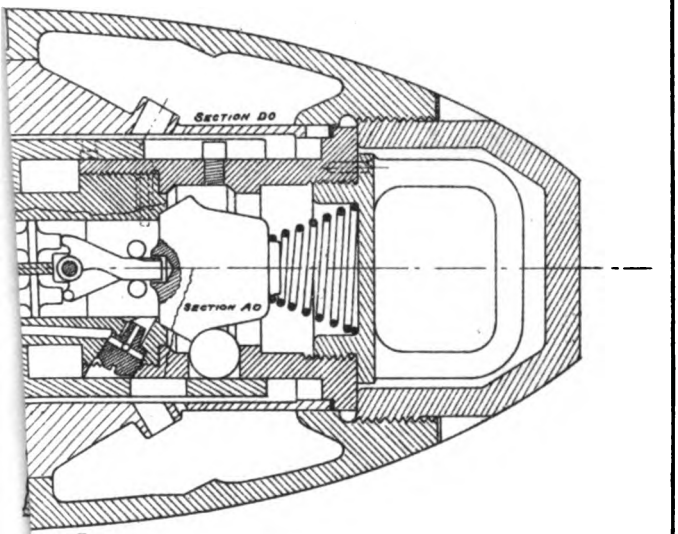

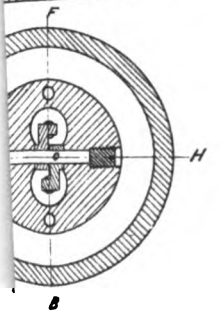

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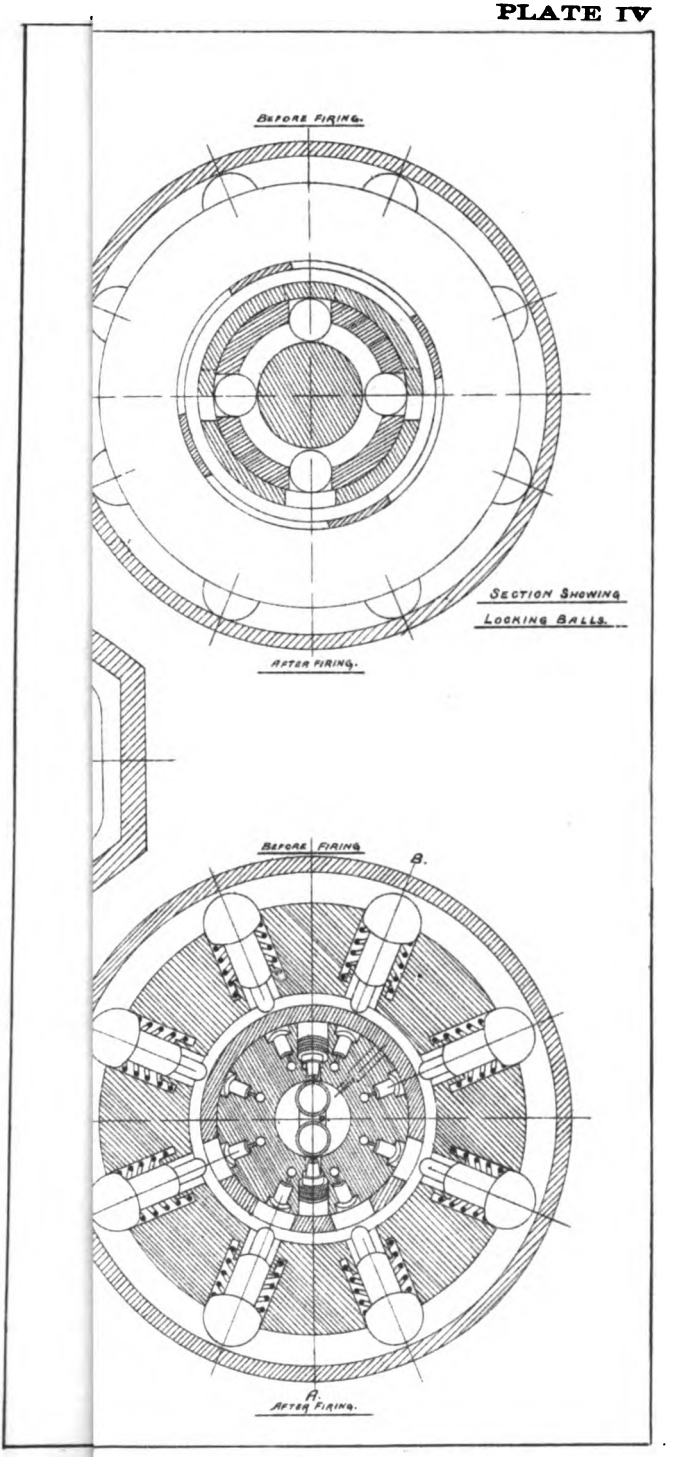

Appendix 32. 1894.

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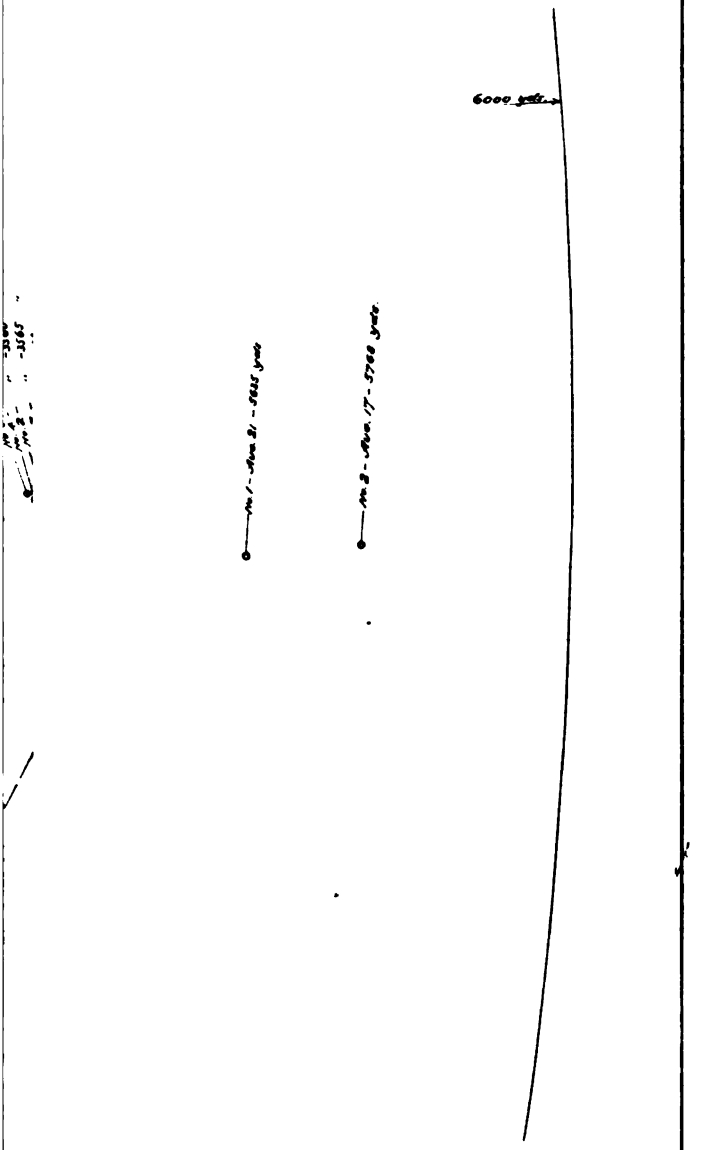

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APPENDIX 33.

TEST OF 6-POUNDER DRIGGS-SCHROEDER RAPID-FIRE GUN.

(8 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, October 9, 1894.

SIR: The following report of the test of a 6-pounder Driggs-Schroeder rapid-fire gun is respectfully submitted:

DESCRIPTION.

The gun is built up, and consists of a tube, jacket, and hoop. The breechblock engages in the jacket. The general construction of the gun body is shown on Plate I, and the parts are assembled in the following manner:

The hoop, the first piece to be shrunk on the tube, is expanded by heat and slipped on from the muzzle end until the shoulder on its interior is close against a corresponding shoulder on the tube, and it is firmly held in this position until cold. The jacket is then put on in like manner from the breech end. On the exterior of the gun is cut a screw thread, part of which is on the hoop and part on the jacket, and on this is screwed the trunnion band for non-recoil mounting, or saddle for recoil mounting, thus locking the entire system and preventing any longitudinal motion between tube and either jacket or hoop. The rifling is to the right with an increasing twist. The curve connecting the initial and final angles is a semicubic parabola.

DESCRIPTION OF MECHANISM (PLATE II).

The transverse hole through the block for the axial, or main bolt, B, is lengthened in a nearly vertical direction to permit the block to descend and disengage the bands from the corresponding grooves in the breech. The main cam, C, has a hexagonal bearing on the main bolt; it will be noticed in Plate III that its front upper face takes under an interior surface in the block and sustains it in the upper or "closed" position. This interior surface inclines upward to the rear, and when the cam is turned to the rear, for opening, this permits the block to descend, the lower rear corner of the cam taking on the interior bottom surface of the block and forcing it down. Conversely, in the latter part of the closing motion, that same upper front face taking under the incline, pushes the block up into place and then slightly takes under the curved surface; in this position the downward thrust of the block has no tendency to turn the cam, and it is therefore held rigidly and securely in place.

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When the main cam has been turned and the block pushed down sufficiently far to clear the bands from the grooves, the semicircular score in the upper rear corner engages the pin L in the block, and, from that time on, the movements of the two are in unison, rotary to the rear around the main bolt, the rear face of the block finally resting on the tray, T, leaving the chamber open.

The firing pin is marked F; the firing spring lies to the rear of its upturned head; the full-cock stud will be noticed under the rear part; the sear, S, actuated by its spring, D, presses up against it and engages the stud as the firing pin is forced to the rear. The point of a lug projecting from the under side of the firing pin rests always in a circular groove hollowed out in a vertical plane in the upper rear face of the main cam. When the cam is turned to the rear, the first effect produced is to push back that lug and the firing pin, so that the point of the latter is brought safely within the face of the block before it begins to descend; the motion continuing, the firing pin is retracted until the full-cock stud passes beyond the sear and is engaged by it. This compresses the firing spring, M. When the sear is pressed down, the firing pin is released and the spring impels it forward. The firing-pin wrench, Q, serves to cock the gun without opening the breech.

The extractors, E, one on each side, lie flat against the rear face of the tube of the gun, and in recesses in the front face of the block. They revolve on pivots, P, which work in recesses in the curtain. The rear sides of the tails of these extractors form cam surfaces; the lower front corners of the block are similarly surfaced, the curves being slightly eccentric to the main bolt, so that after the block has been lowered during its rotation its cam surfaces take upon the extractor tails, pressing them forward and consequently bringing the extractor heads to the rear and throwing the cartridge case out. These bearing surfaces are so adjusted that the motion is slow at first, with a powerful leverage; toward the latter part of the rotation of the block the motion imparted is quick.

But one thing now remains to be explained. The block, as already described, has a certain amount of vertical motion with regard to the main bolt, and must be kept in the lower position relative to it during the rotation. To this end a pin, or "guide bolt," G, is screwed in through each side of the curtain, projecting into a guide groove cut in each side of the block; this groove is so shaped that the bolt permits only the vertical and rotary motions of the block in succession, thus confining it in its movement. It also performs one other function: In closing the breech, after the rotary motion of the block ceases, the vertical motion is produced by the upper corner of the cam pressing on the interior inclined surface of the block; for the purpose of easing an otherwise abrupt change of motion (from rotary to vertical), the part of the guide groove where the guide bolt is at that instant, is cammed so as to make the bolt start the block upward gently before the corner of the main cam touches the incline; the motion of rotation thus merges gradually and easily into that of vertical translation.

Among the principal details may be mentioned the following:

The bands on the top and side of the block, and the corresponding grooves in the breech, are inclined about 2 degrees and 30 minutes to the front and upward, so that, as the block is pushed up into position in closing, it is also pressed forward and presses the cartridge case home, and in opening it readily detaches itself from the head of the case.

The sear, which slides vertically in the middle of the rear face of the block, has a left arm at its lower end against which the sear spring bears.

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The design of shoulder bar used in this test is provided with a pistol handle. The trigger in the handle is connected directly with the sear by a lanyard.

To facilitate assembling, the front face of the block contains a heavy face plate, K, easily removed and secured. The cam, firing pin, and spring are removed and replaced there.

NOMENCLATURE (PLATE III).

A. Breechblock.
B. Main bolt.
C. Main cam.
D. Sear spring.
E. Two extractors.
F. Firing pin.
G. Two guide bolts.
H. Operating handle.
K. Face plate.
L. Spring feather, locks H to B
M. Firing spring.
N. Firing-pin point
S. Sear.

OPERATION.

The operating handle H is on the left side.

To open the breech, eject the empty case, and cock the firing pin, the handle is turned smartly to the rear. During the progress of this movement the firing pin is retracted until the sear catches in front of the full-cock stud; the extractors are pivoted, heads to the rear, ejecting the empty cartridge case; the block finally lands on the tray.

A fresh cartridge is then placed in the chamber and the handle turned to the front. This closes the breech, by first turning and then raising the block, the firing pin being left in the full-cock position.

If the exercise is to be carried on without ammunition, the drill washer R should be slipped on the rear end of the firing pin so as to take against the rear face of the block in snapping and secured there by V. This saves the firing-pin point from striking the face plate, which would injure it in time. The drill washer should not be left on when not exercising, as it keeps the firing spring slightly compressed, which has a tendency to diminish its strength.

TO DISMOUNT AND ASSEMBLE.

The block is held within the gun by the main bolt and the two guide bolts. To dismount, therefore, start with the block closed and back out the guide bolts with the screw-driver far enough to clear the block; cock the mechanism to preserve the firing-pin point from possible injury; take off the handle; tap the main bolt gently to start it; withdraw it completely, supporting the block with the hand; lower the block out of place, tilting it slightly to the rear, so as to clear the extractors.

The block being out and the mechanism still cocked, to dismount the latter remove the face plate, using a hammer and a copper drift. When the face plate is off, ease the firing pin forward. Take out the main cam, firing pin, main spring, sear spring, and sear in the order named.

To assemble the mechanism, proceed in the reverse way. Put in successively the main spring, firing pin, and main cam. The front side of the latter is marked "out." The mechanism must be cocked before putting on the face plate. An arrow on the head of the main bolt being brought in line with the arrow on the curtain indicates the proper "square" for the hexagonal bearing in the cam.

SIGHTS.

The sights used on Driggs-Schroeder guns, Pl. IV, have been designed with the object of securing fine, accurate alignment and at the same

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time providing the ordinary notch and point for use at close quarters or when rapidity of fire is more important than extreme accuracy.

The drift, due to the twist of the rifling, is compensated for by setting the sight bar at a permanent angle to the left. The sight is provided with a drift scale graduated to 10 minutes of arc.

An essential feature of sights for rapid-fire guns is that they shall be capable of rapid changes of setting and with but one hand. They must also remain securely in the position in which they are left. The present sights accomplish this.

For accurate shooting the rear sight has double cross wires and the front sight single wires. The advantages of this arrangement are that the gun can be pointed almost as accurately as with a telescopic sight, and that there is a clear field about the target.

Each space on the sight bar represents 100 yards in range when using the service charge. To set the bar at any desired range, disengage the operating wheel by pulling it to the right with the right hand; then turn it until the desired graduation is on a line with the top of the sight box. As soon as the wheel is let go it will engage the teeth on the side of the sight box and remain in that position, thus preventing the bar from any downward motion.

The notch on the top of the eyepiece and the point on the top of the front sight are used for quick sighting, or as a finder when using the cross wires. With them the piece may be approximately pointed, and, if there is time, the aim corrected with the cross wires.

ACCESSORIES.

The accessories, Plate IV, consist of the following:

1. Hand extractor.
2. Combination screw-driver and wrench.
3. Babbitt metal mallet.
4. Face-plate drift.
5. Oil can.
6. Block support.
7. Firing-pin wrench.
8. Cleaning brush.
9. Sponge, brush, and rod.
10. Drill washers.

For convenience of handling and stowing these parts, excepting the sponge rod, are kept in an accessory chest. The block support was furnished with the first 6-pounders, but was found unnecessary and has been omitted.

With the exception of the drill washer, these pieces require no explanation. The washer is of rubber, and for drill purposes is put on the rear of the firing pin, between it and the rear face of the block, where it is secured by the brass washer Y, a pin on which passes through a hole in the firing pin and retains both washers. With the drill washer on, the piece may be snapped without danger of breaking the firing-pin point; if snapped without this washer the point is liable to injury, while the blow on the face plate will in time injure it and the front of the firing pin. (See photograph).

FUSES (PLATE. V).

The fuse used with all ammunition other than shrapnel, issued by the Driggs Ordnance Company, is the Driggs percussion fuse, usually constructed for application as a base fuse. With shrapnel a time fuse is used.

The parts of the fuse are the body, the plunger or pellet, the spring, and the detonating cap.

The body is of gun metal, the rear end having a broad thin flange, which serves as a gas check. Forward of this a thread is cut for screw-

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ing into the projectile. The plunger is also of gun metal and at its rear end has a circular score cut to receive the two lugs of the spring. The forward end is provided with a blunt point for exploding the cap upon impact. The spring is of tempered steel, and is bent so as to form two arms, having at their lower ends circular lugs.

The detonating cap consists of a hollow brass cap filled with fulminate of mercury and is contained in the screw cap which screws in in front of the spring and plunger.

The parts are so assembled that the rear end of the plunger normally rests upon the interior bottom of the body.

The two circular lugs of the spring fit in the score of the plunger, pressing into it with a strength that can only be overcome by the centrifugal force produced by a high velocity of rotation. When the gun is fired the rotation given the shell by the rifling causes the arms and lugs of the spring to open out away from the center sufficiently to release the plunger, thus arming the fuse. Upon impact the plunger goes forward and explodes the cap, the flame from which passes through two vent holes in the top of the fuse and into the shell.

CARTRIDGE (PLATE VI).

All the cases used with the Driggs-Schroeder ammunition are solid drawn.

The ignition is derived from a detonating cap, which is the same for all calibers. With field ammunition which may be subjected to violent jolting over rough ground a safety cap is used to prevent any possible jar from igniting the fulminate cap and exploding the charge. Both steel and common shell are supplied.

Ammunition.

	H. P. mark II.
Steel shell:	
Total length.....inches..	8.58
Weight of shell.....pounds..	5.76
Weight of burster.....do....	.22
Weight of fuze.....do....	.133
Weight, total.....do....	6.11
Common shell:	
Total length.....inches..	8.39
Weight of shell.....pounds..	5.43
Weight of burster.....do....	.22
Weight of fuze.....do....	.133
Weight, total.....do....	5.78
Fixed ammunition:	
Total length (steel shell).....inches..	.....
Total length (common shell).....do....	.....
Weight of empty case.....ounces..	.....
Weight of charge.....do....	48
Weight of felt wad.....do....	.25
Total weight (steel shell).....pounds..	.....
Total weight (common shell).....do....	.....

Range table.

Initial velocity	foot-seconds..	1,914
Diameter of projectile	inches..	2.244
Weight of projectile	pounds..	6
Length of projectile	calibers..	3½
Radius of ogival	do....	2½
Permanent angle of sight bar	degrees..	2
Radius of gun	inches..	35.111

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Range table—Continued.

Range.	Height of sight bar marks.	Angle of elevation.	Angle of fall.	Remaining velocity.	Time of flight.	Range.	Height of sight bar marks.	Angle of elevation.	Angle of fall.	Remaining velocity.	Time of flight.
Yards.	*Inches.*	° ′	° ′	*Ft. sec.*	*Secs.*	*Yards.*	*Inches.*	° ′	° ′	*Ft. sec.*	*Secs.*
100	.045	0 04.4	0 04.9	1,854	0.16	2,900	2,628	4 16.7	6 45.5	935	7.06
200	.095	0 09.4	0 10	1,796	0.32	3,000	2,775	4 31	7 10.3	923	7.38
300	.148	0 14.5	0 15.5	1,739	0.49	3,100	2,925	4 45.7	7 35.6	912	7.71
400	.203	0 19.8	0 21.5	1,684	0.67	3,200	3,080	5 00.7	8 01.7	901	8.04
500	.259	0 25.3	0 28.1	1,631	0.85	3,300	3,241	5 16.2	8 28.4	890	8.38
600	.317	0 31	0 35.3	1,579	1.04	3,400	3,407	5 32.3	8 55.8	879	8.72
700	.378	0 37	0 43	1,529	1.23	3,500	3,575	5 48.6	9 23.9	869	9.07
800	.443	0 43.3	0 51.4	1,480	1.43	3,600	3,745	6 05.1	9 52.8	859	9.42
900	.510	0 49.9	1 00.4	1,434	1.63	3,700	3,920	6 22	10 22.9	849	9.78
1,000	.580	0 56.7	1 10.1	1,389	1.85	3,800	4,100	6 39.4	10 53.9	840	10.14
1,100	.653	1 03.9	1 20.8	1,346	2.07	3,900	4,286	6 57.2	11 24.7	831	10.50
1,200	.730	1 11.4	1 32.6	1,305	2.30	4,000	4,476	7 15.6	11 57.1	822	10.87
1,300	.811	1 19.3	1 45	1,266	2.53	4,100	4,671	7 34.4	12 30.1	814	11.24
1,400	.895	1 27.5	1 58	1,229	2.77	4,200	4,869	7 53.4	13 03.9	806	11.62
1,500	.982	1 36.1	2 11.6	1,196	3.02	4,300	5,073	8 13	13 38.4	798	12 00
1,600	1.073	1 45	2 26.6	1,166	3.27	4,400	5,283	8 33.1	14 13.8	790	12.38
1,700	1.17	1 54.4	2 42.2	1,140	3.53	4,500	5,499	8 53.7	14 50.1	783	12.77
1,800	1.272	2 04.4	2 58.2	1,115	3.80	4,600	5,719	9 14.8	15 27.3	776	13.16
1,900	1.376	2 14.6	3 15.2	1,092	4.07	4,700	5,945	9 36.3	16 05.4	769	13.56
2,000	1.483	2 25	3 33.2	1,071	4.35	4,800	6,178	9 58.4	16 44.5	762	13.97
2,100	1.594	2 35.7	3 52.2	1,052	4.63	4,900	6,416	10 21	17 24.7	755	14.38
2,200	1.709	2 47	4 11.6	1,035	4.92	5,000	6,660	10 44.1	18 05.8	748	14.79
2,300	1.828	2 58.7	4 31.6	1,018	5.21	5,100	6,910	11 07.7	18 47.9	741	15.20
2,400	1.950	3 10.6	4 52.6	1,002	5.51	5,200	7,168	11 31.9	19 30.9	735	15.62
2,500	2.075	3 22.8	5 14.2	987	5.81	5,300	7,432	11 56.7	20 15.0	729	16.05
2,600	2.207	3 35.6	5 36	973	6.11	5,400	7,704	12 22.1	21 00.2	723	16.48
2,700	2.345	3 49.1	5 58.2	960	6.42	5,500	7,984	12 48.2	21 46.5	718	16.92
2,800	2.485	4 02.8	6 21.2	947	6.74						

The following programme was adopted for the test:

The gun to be carefully examined by the board. The number of parts of the breech mechanism, their strength, simplicity, and certainty of action to be noted; also the ease, safety, and certainty of the breech mechanism as a whole. Note especially the action of the firing pin and extractor, and the maximum outward position of the cartridge when it can be pushed home by the breech block. During this examination 50 rounds to be fired at will.

VELOCITY.

Five rounds to be fired for velocity with full charges.

ACCURACY.

Ten rounds to be fired at each range of 1,000 yards, 1 mile, and 3,000 yards, the same conditions of aiming being repeated at each round, and the mean deviations determined.

RAPIDITY.

Determine number of rounds that can be fired in 5 seconds, three trials; also number of rounds that can be fired in 1 minute, 3 minutes, and 5 minutes, respectively; and finally the time required to fire 100 rounds, noting carefully during the firing, and especially at end of each 25 rounds, the condition of the gun as regards heat, and ease, and certainty of action.

Two detachments of men, alternating every 25 or 50 rounds, as may be thought advisable.

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RAPIDITY WITH ACCURACY.

Fire 10 aimed shots as rapidly as possible at the 1,000 yards and 1 mile targets. Also 10 aimed shots at targets in same line and ranges of 500 and 1,000 yards, alternately; also 10 aimed shots alternately at targets at about 500 yards range, placed about 75 feet apart.

DUST.

The mechanism to be exposed to a blast of fine dust in such manner as to insure its being uniformly and equally covered with the dust, after which 20 rounds to be fired as rapidly as possible.

EXCESSIVE CHARGES.

The gun to be fired with 5 charges, giving gradually increasing pressures up to 45,000 pounds per square inch, if such pressures are attainable.

DEFECTIVE CARTRIDGES.

The gun to be tested with defective cartridges in the same manner as is usual in the trial of small arms.

Any rounds that may remain after the above tests to be expended in such manner as may be deemed best by the board as a result of the circumstances developed; the last 5 rounds to be fired after the mechanism of the gun has been rusted in a thorough and uniform manner.

The test, in accordance with the programme, was commenced on May 1 last.

The length of the gun is 50 calibers from the seat of the head of the cartridge case to the muzzle. The action of the mechanism in manipulation and deliberate firing was found to be satisfactory, except that the short chain lanyard connecting the seat with the trigger of the pistol grip was not strong enough for its purpose. It was broken a number of times during the test, and after the two hundred and seventeenth round was replaced by a small wire rope, which did not break. All parts of the mechanism are very securely housed in and protected, so that it is well disposed to stand exposure to the weather. The piece can not be fired before the block is closed, although the sear can be disengaged; recocking is, however, possible, by means of a small tool provided for the purpose, without opening the breech. The breechblock is light and the manipulation easy and requiring little exertion; three men efficiently serve the piece, one to pass the ammunition, one to load and handle the block, and one to aim and fire. The lightness of the breechblock and its housing also allows the use of a long gun without great total weight, and the realization of high velocity. If a cartridge case should be stuck in the chamber, the mechanism can be dismounted and the case driven out from the front. The block seems to have no tendency to fly open upon firing. The cartridge can be pushed home by the block in closing when it is at a distance of 3 inches from its seat.

Starting with the breech closed, the mechanism was removed and completely dismantled by one man, the representative of the gun, in 37 seconds, using one special tool. It was assembled, replaced in the gun, and the motion of firing executed in 4 minutes 5⅜ seconds, but as the operator was nervous and fumbled considerably, a second trial was

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allowed, when the time occupied was 1 minute 30 seconds. A test was made of the time required to fire one shot, remove and replace main-spring, sear spring, firing pin, and extractors, these being the parts most liable to injury during action, and fire a second shot. The time between the two shots was 2 minutes 4¼ seconds.

The weight of the breech mechanism complete, including extractors and handles, is 35¼ pounds, and the number of its parts 15.

VELOCITY.

The maximum velocity obtained in firing five rounds was 1,911 foot-seconds; the minimum, 1,859 foot-seconds, and the mean, 1,891 foot-seconds.

ACCURACY.

At 1,000 yards range the mean vertical deviation of 10 shots from the center of impact was .74 foot, the mean horizontal deviation was .8 foot, and the mean deviation 1.09 feet. One sighting shot was used, and there were no misses.

At 1 mile range there was one sighting shot and ten shots at the target, all of which were hits, the mean vertical deviation being 1.3 feet, mean horizontal deviation 1.82 feet, and mean deviation 2.24 feet.

At 3,000 yards range there were first four sighting shots, when firing was suspended to give that at 1,000 yards range precedence. At the second attempt there were six sighting shots, then ten at the target, of which nine were hits, the mean deviations of the nine being: Vertical, 5.28 feet; horizontal, 6.3 feet; absolute, 8.22 feet. A wind of 20 miles per hour was blowing from the right and rear. The aim is disturbed both in elevation and direction by the discharge.

The targets are represented on Plate VI.

RAPIDITY.

The number of rounds fired in 5 seconds was: At the first trial, 3; at the second trial, 3; at the third trial, 3, with one left in the chamber.

The number of rounds fired in 1 minute was 32, and in 3 minutes 83. Of the 83, one missfire counted as a round fired, and in three instances the trigger was pulled before the block was closed, the block being opened again to cock the mechanism. Had these three cartridges been thrown out and counted as rounds fired the number would have been increased to 85 or 86. The 32 rounds were fired in the first minute of the 3-minute test. The officers loading and firing exchanged places at the end of 1½ minutes.

At the first attempt to fire rapidly 100 rounds the lag screws holding the mounting to the platform pulled loose, and after firing 55 rounds the piece was transferred to another mounting. The time of firing 100 rounds was 6 minutes 41⅗ seconds, of which 26 seconds were consumed in replacing the defective lanyard 3 times, and 2 minutes 6 seconds in replacing the sear spring broken at the eighty-ninth round of the 100.

The ammunition was placed on a table in rear of the piece and close to it. Three persons—two officers and one enlisted man—were employed in the service. The officers loading and firing exchanged places after each 25 rounds. The mechanism worked satisfactorily throughout, with the exception of the broken lanyard and sear spring noted.

After firing 75 rounds, soft solder would melt anywhere along the chase, showing a temperature of about 375° F.

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RAPIDITY WITH ACCURACY.

In firing for rapidity with accuracy at 1,000 yards range, 7 sighting shots were used, then 10 shots at the target, all of which were hits, the deviations being as follows: Mean vertical, 1.61 feet; mean horizontal, 2.06 feet; mean, 2.61 feet. The time required for the 10 shots was 1 minute 10½ seconds.

At 1 mile range 4 sighting shots were used, followed by 10 hits upon the target; deviations, mean vertical, 3.75 feet; mean horizontal, 2.9 feet; mean, 4.74 feet. Time for the 10 shots, 1 minute 36½ seconds.

At 2 targets in the same line at ranges of 500 and 1,000 yards, 1 sighting shot at the 1,000-yard target and 5 at the 500-yard target were followed by 10 at each alternately. All were hits, and the deviations were: At 500-yard target, mean vertical, 1.995 feet; mean horizontal, 1.121 feet; mean, 2.288 feet; at the 1,000-yard target, mean vertical, 1.46 feet; mean horizontal, 2.033 feet; mean, 2.507 feet. Time for the 20 shots, 5 minutes 27⅝ seconds. The sight was adjusted for each shot at each target.

At 500 yards range 2 targets were placed 80 feet apart, and after 4 sighting shots at No. 1 and 1 at No. 2, 10 shots were fired alternately at each. There were 10 hits upon target No. 1, of which the deviations were: Mean vertical, 1.69 feet; mean horizontal, 1.135 feet; mean, 2.036 feet. Upon target No. 2 there were 8 hits, two of the shots having struck a telegraph pole in the line with the target. Of the 8 shots the deviations were: Mean vertical, 1.50 feet; mean horizontal, .612 foot; mean, 1.624 feet. The time required for firing the 20 rounds was 2 minutes 59⅝ seconds.

During all this firing the shock from the shoulder bar, due to the recoil, was very severe.

A representation of the targets is inclosed, Plate VII.

DUST.

There were two tests made of the effects of dust upon the mechanism. After the firing with defective cartridges the gun was taken to the blacksmith shop to be dusted, without any part being cleaned in any degree. Care was exercised to avoid removing residue from the breech mechanism in handling the gun. The gun was cocked.

The blue prints attached to the firing record show the method adopted for dusting the mechanism. "A" is a lead pipe leading from the pine box "C" to the hand bellows in the blacksmith shop.

The dust used was burnt sand from the proof butts. The passage of the projectile through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose.

The gun was subjected to a blast of dust for 8 minutes, 2 men working the bellows as uniformly as practicable.

One blue print shows the apparatus at work; the other shows it at rest.

After being dusted the gun was remounted and the time to open the breech block and fire 5 rounds was noted.

Time, 3 minutes 20 seconds. The block was opened at the first attempt, but the firing pin twice failed to explode primer; at the third attempt it fired all right.

The mechanism was not cleaned at all; neither oil nor water was used on it. The dust was not removed from the bore. The main bolt bind-

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ing slightly, though still serviceable and comparatively easy to work, was taken to the machine shop and found slightly bent near the middle of its length. It was straightened and replaced.

In the second dust test all the parts of the mechanism were thoroughly washed with hot water and soap; they were then carefully dried and slightly oiled.

When subjected to the blast of dust the gun was not cocked.

The arrangement for dusting and the material used were the same as in the first dust test.

The gun was subjected to a blast of dust for 8 minutes.

The block opened without difficulty by one man, and the 5 rounds were fired with very little trouble. The bore was not wiped out.

No oil or water was used on the block.

Time to open block and fire 5 rounds, 55½ seconds.

Five rounds instead of 20 were fired after dusting because of scarcity of ammunition.

EXCESSIVE PRESSURES.

At the first round for excessive pressure 2 ounces of rifle powder were added to the charge; at the second and third rounds 2¼ ounces; at the fourth round 1 ounce, and at the fifth round 1½ ounces. The pressures were respectively 40,560, 46,311, 49,111, 37,382, and 39,964 pounds per square inch.

The mechanism worked well after this test, although it is probable that the bending of the main bolt noted under the head of the dust test was caused by the excessive pressures.

DEFECTIVE AMMUNITION.

Defective cartridges prepared in three ways were used; in the first method the cartridge case was prepared by filing obliquely through the edge of the rim, so as to just show an opening to the interior at the junction of the head and wall. The slots were at the extremities of two diameters at right angles with each other. The cartridge was placed in the gun so that the solid part of the rim came opposite the extractors.

There was quite an escape of gas as a matter of course. The breech block could not be opened by hand at all and a mallet was used on the handle. After some difficulty the block was opened and water thrown over it to remove the residue.

The second cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other and each was half way between the primer and the rim. The breech block was opened after firing with considerable difficulty, using the same method as in the previous round. Water was thrown over the block.

A service cartridge was then fired at the first attempt, showing all parts in working order. The block was opened with very little difficulty.

Time to fire 2 defective and 1 service cartridge, fifteen minutes.

Three blowbacks were then procured by unloading the requisite number of rounds, decapping the cases and thinning the metal of the primers; the cases were recapped and the charges replaced.

The first and second blowbacks caused no delay save what was necessary to aim the gun on the butt.

Of the third blowback the primer failed at least half a dozen times, and three or four of these times the long lanyard broke and had to be

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tied. A service cartridge procured from No. 6 magazine was fired at the first attempt, showing the mechanism in order. Time, 6 minutes 23 seconds. Another case was ordered prepared for the third blowback.

The firing pin was tapped once or twice with a mallet after the second failure to explode the third blowback; the primer was found well indented.

The 6 minutes and 25 seconds comprise the whole time involved, including getting and firing the service cartridge.

After three-quarters of an hour the third blowback was ready and was fired at the first attempt.

It then required three attempts to fire a service cartridge. The three blowbacks blew out the primers and there was plenty of gas escaped into the mechanism.

Time to fire 2 blowbacks and 1 service, 6 minutes 25 seconds.

Time to fire third blowback and 1 service, 33¼ seconds.

Total time, 6 minutes, 58¼ seconds.

RUST.

Before rusting the breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap.

The gun was not cocked. The handle and rear sight were removed; the screws holding sight in place were replaced to prevent rust from getting into the holes. Before immersing, a soft wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber. The gun was immersed in solution of 15 per cent sal ammoniac and 85 per cent of water by weight; it was suspended with the axis vertical, and was lowered into the solution just enough to cover the breech mechanism.

The gun was in the solution 25 minutes. It was allowed to stand undisturbed for 48 hours, after which time the operation of opening the breechblock was commenced. The breechblock could not be opened by hand nor by using a wooden mallet on the handle. At the end of 1½ minutes oil was used to soften the rust and the effort to open the block was continued. After 10 minutes, having failed to open the block, the main bolt was driven out and a copper drift was used on the block to jar it loose from its seat. At the end of 25 minutes the breechblock was out of the gun. The breech mechanism was then dismantled and all the parts wiped and oiled. The parts were well rusted, and as a rule a copper drift had to be used to separate them one from another. After being oiled, the mechanism was assembled and replaced in the gun, the time consumed up to this point being 1 hour and 5 minutes.

Five service rounds were then fired as rapidly as practicable, the total time required being 1 hour 8 minutes 4½ seconds.

This completed the programme.

At the fifth round of the above-described test, a washer at the front end of the hydraulic cylinder stuck on the piston rod and held the recuperator spring in compression so that the piece was not returned to battery. The cylinder was dismounted and a clearance given to the washer, after which it gave no further trouble.

The same parts of the breech mechanism were used throughout the test, with the exception of the broken lanyards and sear spring noted, and no part required repair or adjustment except the bent main bolt discovered during the dust test.

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The loading and firing were done by Lieut. M. F. Harmon, First Artillery, and Lieut. F. P. Peck, Ordnance Department. During most of the critical parts of the test the representatives of the gun were present.

The following table shows the general results of the test, which was finished on June 26, 1894, 441 rounds being fired:

Weight ..... pounds..	786
Caliber ..... inches..	2.244
Length ..... calibers..	50
Weight of breech mechanism ..... pounds..	35½
Number of parts of breech mechanism	15
Time to dismantle breech mechanism ..... seconds..	37
Time to assemble breech mechanism	1m 30s
Distance from seat in chamber at which breech block will force cartridge home ..... inches..	3
Time to fire 1 round, change mainspring, sear spring, firing pin, and extractor, and fire another round	2m 4s
Time to fire 100 rounds	4m 35½s
Number of rounds fired in 1 minute	32
Number of rounds fired in 3 minutes	83
Number of rounds fired in 5 seconds, first trial	3
Number of rounds fired in 5 seconds, second trial	3
Number of rounds fired in 5 seconds, third trial	3
Time to fire 2 defective and 1 service cartridge ..... minutes..	15
Time to fire 5 rounds after dusting, first test	3m 20s
Time to fire 5 rounds after dusting, second test ..... seconds..	55½
Time required to fire 3 blowbacks and 1 service cartridge	6m 58½s
Time required to open breechblock and fire 5 rounds after rusting	1h 8m 4.5s
Mean velocity ..... foot-seconds..	1,891

	Accuracy.			Accuracy with rapidity.		Alternating two, 500 yards.		Alternating 500 and 1,000 yards.	
	1,000 yards.	1 mile.	3,000 yards.	1,000 yards.	1 mile.	No. 1.	No. 2.	500 yards.	1,000 yards.
Mean vertical deviation....feet..	.74	1.3	5.28	1.61	3.75	1.69	1.50	2	1.47
Mean horizontal deviation..do...	.8	1.82	6.3	2.06	2.9	1.14	.61	1.12	2.03
Mean deviation .....do...	1.09	2.24	8.22	2.61	4.74	2.04	1.62	2.29	2.51
Number of hits.....	10	10	9	10	10	8	10	10	10
Number of misses.....	0	0	1	0	0	0	0	0	0
Time to fire	.....	.....	.....	2m 10½s	1m 36½s	.....	.....	.....	.....
Time to fire both targets	.....	.....	.....	.....	.....	2m 59s		5m 27½s	

Firing record and 8 plates are enclosed.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3031)

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches,

[Object of firing,

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
May 2	1						
May 2	2					2	
May 2	3					2	
May 2	4					2	
May 2	5					2	
		Maximum.					
May 2	6	18 6½					
May 2	7	13 0				1⅞	1⅞
May 2	8	10 0				2 1/16	2 1/16
May 2	9						
May 2	10						
May 2	11	10 0				2⅛	2⅛
May 2	12						
May 2	13						
May 2	14						
May 2	15						
May 2	16					2¼	2¼
May 2	17						
May 2	18						
May 2	19						
May 2	20						
May 2	21						
May 2	22						
May 2	23						

[To obtain

May 3	24						
May 3	25		1,906 1,915				
May 3	26		1,884 1,892				
May 3	27		1,856 1,861				
May 3	28		1,886 1,892				
May 3	29		1,906 1,906				
			50+1 12/16				

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weight 786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28 1894

test of gun.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		This gun is 50 calibers long from seat of head of cartridge case to muzzle. Weight of breechblock and breech mechanism complete, including extractors and handle, 35¼ pounds. The breech mechanism consists of 15 pieces. Starting with the breechblock closed, the breech mechanism was removed and dismantled by 1 man (representing the gun) in 37 seconds, using no tools except the firing-pin wrench. The mechanism was assembled, replaced in the gun, and the motion of firing executed in 4 minutes 5⅘ seconds. Upon being allowed a second trial the operation was completed by 1 man in 1 minute 30 seconds. In the first attempt to assemble the mechanism the principal difficulty was to get the main bolt in place; it was caused to a great extent by excessive anxiety and consequent fumbling, a second man finally assisted. This is why a second attempt was permitted. The time was taken by the proof officer, using a stop watch which reads to one-fifth of a second. Lieuts. Harmon, First Artillery, and Peck, Ordnance Department, did all the loading and firing. The gun is fired by means of a chain lanyard fastened to the pistol grip on shoulder bar. The breechblock will force the cartridge home when it is 3 inches short of its seat in chamber. Recoil produces a decided blow on the shoulder. The lever for clamping the elevation is not satisfactory; the muzzle rises slightly upon firing. The piece on shoulder bar which prevents the cartridge case from striking the operator cuts the hand (since corrected). At discharge both elevation and direction change; in direction, muzzle left.
	Filling washer at front end of recoil cylinder stuck on the piston rod and held spring in compression so the piece was not returned to battery. Cylinder dismounted and a clearance given to washer.	
	After firing these three rounds the gun was 1⅛ inches out of battery, but when depressed it returned again.	
	Fired to sea	
	Fired into sand butt	
	Chain lanyard broke; repaired	
	Chain lanyard again broke. Fired into sand butt.	

velocities.]

	Warming charge. Fired to sea.	

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weigh

[For rapidity

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		° '	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
May 4	30						
May 4	31						
May 4	32 to 41						
May 8	42 to 96						
May 10	97 to 99					1 1/16	
May 10	100 to 199					2 1/16	

[Test gun for acc

		Quadrant.					
May 11	200	4	31			0	
May 11	201	4	43			1/8	
May 11	202	4	50			1/8	
May 11	203	4	50			1/8	

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

100 rounds.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Fired to sea to note the place of striking.	
.....	Chain lanyard broke; a rope one substituted.	
.....	Fired into sand butt; smoke interfered and firing suspended.	
.....	A new chain lanyard attached; 55 rounds were fired in 3 minutes and 53 seconds, and firing had to be suspended. The lag screws holding mount became loose. There were three misfires during the first 24 rounds.	The misfires were not due to defective cartridges, but were caused by pulling the trigger before the block was completely closed. The sear can be disengaged in this manner, but it is impossible for the firing pin to strike the primer until the block is completely closed.
	Gun with recoil cylinder and attachments changed to mount for Seabury gun before firing May 10, 1894.	Soft solder melts along chase at the end of 75 rounds.
.....	Fired to sea to note the place of striking.	In firing for rapidity, the ammunition was placed on a table in rear of the gun and as close to it as possible without interfering with the handling of the gun. Taking the ammunition from this table, 3 men served the gun.
.....	Total time to fire 100 rounds, including repairs to sear spring and time to allow ships to pass, 11 minutes 17¾ seconds. Actual time of firing, 4 minutes 35¾ seconds.	Lieuts. Harmon and Peck alternated in loading and firing. The changes were made after each group of 25 rounds.
	Round 175, chain lanyard nearly broken and changed. Round 187, lanyard broke; repaired. Round 188, lanyard broke; repaired. Round 189, sear spring broken; time to replace sear spring, 2 minutes and 6 seconds.	

acy at 3,000 yards.]

Wind from front and left, 30°, 10 miles an hour.	Elevation by sight, 2,900 yards. Elevation increased 17 minutes on firing. Struck 24 yards in front of target and ricochetted through 11 feet left of center.	
	Elevation by sight, 3,000 yards. Sight jumped up 25 yards on firing. Stuck 14 yards in front and on line.	
	Elevation by sight, 3,050 yards. Struck target 2 feet above and 5 feet left of center.	
	Struck target 2 feet above and 5 feet left of center. Firing suspended to permit Lieut. Peck to make the target at 1,000 yards.	

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Test gun for accu-

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
May 11	204				0		
May 11	205						
May 11	206						
May 11	207						
May 11	208						
May 11	209						
May 11	210						
May 11	211						
May 11	212						
May 11	213						
May 11	214						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

racy at 1,000 yards.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.

Wind front and left 40°, 12 miles an hour. Barometer 30.35; thermometer 54°; humidity, 94.

Sighting shot. Elevation by sight, 900 yards. Chain lanyard broke; repaired. Struck target 6¼ feet below and 4½ feet left. Aimed at top and center of target.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	1	.....	5	.....	0.1	.....	1
.....	3.5	.....	4.5	.....	2.6	.....	.5
.....	.5	.....	4.5	.4	.....	.....	.5
.....	1.5	.....	4.5	.....	.6	.....	.5
.....	1	.....	3	.....	.1	1	.....
0	.....	.....	2	.9	.....	2	.....
.....	1	.....	3	.....	.1	1	.....
.....	1	.....	4	.....	.1	0	.....
.....	1	.....	5.5	.....	.1	.....	1.5
1.5	.....	.....	4	2.4	.....	0	.....

	Feet.
Center of impact—	
Below	0.9
Left	4.0
Mean vertical deviation from center of impact	.74
Mean horizontal deviation from center of impact	.8
Mean deviation from center of impact	1.09

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Test gun for accu-

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		Quadrant.	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
May 14	215	4 50			1	2½	
May 14	216	4 45			1	2½	
May 14	217	4 30			1		
May 14	218	4 37			2		
May 14	219	4 34½			2.1		
May 14	220	4 34½			2		
May 14	221	4 37			1.9		
May 14	222						
May 14	223						
May 14	224						
May 14	225						
May 14	226						
May 14	227						
May 14	* 228						
May 14	229						
May 14	230						
May 14	231						

*Miss: struck 100 yards beyond and slightly left.

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

racy at 3,000 yards.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech-mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 20°, 8 miles an hour; barometer, 30.39; thermometer, 70°; humidity, 43.	Elevation by sight, 3,025 yards. Struck the ground 75 yards beyond and on line. Elevation by sight, 3,000 yards. Struck 50 yards beyond. Elevation by sight, 2,875 yards. Struck 40 yards in front and 10 feet to the left of the left edge. Elevation by sight, 2,910 yards. Struck target 8 feet above and 7 feet left of center. Elevation by sight, 2,900 yards. Struck target 9 feet below and 13 feet right of center. Elevation by sight, 2,900 yards. Struck 2 yards in front and ricochetted through 14 feet below and 8 feet right of center.	Aimed at a board nailed to the upper left corner of target. Target not visible from battery; sight used for direction only. Before this firing a wire cable lanyard was substituted for the chain lanyard.

TARGET.

Direction.	Degrees.	Miles per hour.	From center of target. Vertical. Above.	Vertical. Below.	Horizontal. Right.	Horizontal. Left.	From center of impact. Vertical. Above.	Vertical. Below.	Horizontal. Right.	Horizontal. Left.
Right and rear.	20	8	7	.....	1	.....	8.44	.....	1.22	.....
	10	8	.....	5	.....	4	.....	3.56	.....	3.78
	10	9	5	.....	3	.....	6.44	.....	3.22	.....
	10	9	6	.....	1	.....	7.44	.....	1.22	.....
	10	10	.....	11	7	.....	.....	9.56	7.22	.....
	10	10	.....	6	11	.....	.....	4.56	11.22	.....
Left and rear.	20	12	0		4	.....	1.44	.....	4.22	.....
	20	12	.....	.....	.....	.....	.....	.....	.....	.....
	20	12	.....	2	.....	13	.....	0.56	.....	12.78
	20	12	.....	7	.....	12	.....	5.56	.....	11.78

Round 221, elevation by sight, 2,910 yards; first to count on target.

Center of impact—	Feet.
Below	1.44
Left	.222
Mean vertical deviation from center of impact	5.28
Mean horizontal deviation from center of impact	6.3
Mean deviation from center of impact	8.22

.....	Struck target 5 feet below and 1 foot right of center.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Test gun for accu-

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
May 15	232	2 4			1		
May 15	233	2 16			1		
May 15	234						
May 15	235						
May 15	236						
May 15	237						
May 15	238						
May 15	239						
May 15	240						
May 15	241						
May 15	242						

[Test for

June 1	243 to 337						

86 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

acy at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind from rear, 12 miles an hour; barometer, 29.93; thermometer, 66°; humidity, 42.	Elevation by sight, 1,600 yards. Struck 100 yards in front and on line.	Aimed at the upper left corner.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
	0	.....	5	.....	0.25	1.3	.....
4	.....	.....	4	3.75	.....	2.3	.....
	0	.....	5	.....	0.25	1.3	.....
.....	0.5	.....	5	.....	0.75	1.3	.....
3	.....	.....	11	2.75	.....	.....	4.7
.....	2	.....	7	.....	2.25	.....	0.7
	0	.....	6	.....	0.25	0.3	.....
.....	2	.....	10	.....	2.25	....	8.7
	0	.....	5	.....	0.25	1.3	.....
	0	.....	5	.....	0.25	1.3	.....

Round 233, elevation by sight, 1,700 yards; first to count on target.

Center of impact—	Feet.
Above	0.25
Left	6.3
Mean vertical deviation from center of impact	1.3
Mean horizontal deviation from center of impact	1.82
Mean deviation from center of impact	2.24

rapidity.]

		Before this firing, the gun with its recoil attachments was replaced on its own mount. Through bolts had in the meantime been substituted for the lag screws, which the firing of May 8 had shown to be insufficient.
		Round 243, fired to sea to note the place of striking.
		Number of rounds fired in 1 minute, 32.
		Number of rounds fired in 3 minutes, 83, and 1 in the gun at the command "stop." In addition, there were three cases in which the trigger was pulled before the block was closed, and in each case the block was opened to cock the mechanism, closed again, and the round then fired.
		One missfire counted as a round fired.
.....	.....	The number of rounds fired in 1 minute was determined by noting the number fired in the first minute of the 3-minute test. The arrangement of the ammunition and the number of men serving the piece were the same as in the 100-round test for rapidity. In the 3-minute test, Lieuts. Harmon and Peck alternated in loading and firing, changing at the end of each 1.5 minutes. To fire one shot, dismount block, remove mainspring, sear spring, firing pin, and extractors, replace and fire another shot, 2 minutes 4½ seconds.
		Number of rounds fired in 5 seconds, first trial, 3; number of rounds fired in 5 seconds, second trial, 3; number of rounds fired in 5 seconds, third trial, 3, and 1 in the gun ready to fire at the command "stop."

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Excessive

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 5	338			10, 40,560			
June 6	339			10, 46,311			
June 6	340			49,111			
June 6	341						
June 6	342						
June 6	343			10, 37,382			
June 6	344			10, 39,964			
June 7	345				½		
June 7	346				½		

[Test with defect

June 9	347						
June 9	348						
June 9	349						

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86 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

harges.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	2 ounces rifle powder added to charge.	
.....	2¼ ounces rifle powder added to charge.	
.....	2½ ounces rifle powder added to charge.	
.....	Fired at 1,000-yard target. Elevation by sight, 1,000 yards. Struck target 4 feet above and 3½ feet left of center.	
.....	Fired at 500-yard target. Aimed at bottom and center. Struck target 1½ feet above and 2½ feet left of center.	
.....	1 ounce rifle powder added to charge.	
.....	1½ ounces rifle powder added to charge.	
.....	Fired at 1,000-yard target. Struck target 9 feet below and 17 feet left of center.	These shots were fired while pressure cartridges were being prepared, and there was not time enough to make the targets this date.
.....	Fired at 500-yard target. Struck target 5½ feet below and 2 feet 3 inches left of center.	

ive cartridges.]

.....	The cartridge case was prepared by filing obliquely through the edge of the rim, so as just to show an opening to the interior at the junction of the head and wall. The slots are at the extremities of two diameters at right angles with each other. Cartridge placed in the gun so that the solid part of the rim came opposite the extractors. There was quite an escape of gas as a matter of course. The breechblock could not be opened by hand at all, and a mallet was used on handle. After some difficulty the block was opened and water thrown over it to remove residue.	
.....	The cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior; the slots were at right angles with each other and each was half way between the primer and the rim. Breechblock opened with considerable difficulty, using the same method as in previous round. Water thrown over block.	
.....	Service cartridge. Fired at first attempt, showing all parts in working order. Block opened; very little difficulty.	
	Time to fire two defective and one service cartridges, 15 minutes.	

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weigh

[Dat

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 9	350						
June 9	351						
June 9	352						
June 9	353						
June 9	354						

[For accuracy with rapid-

June 9	355						
June 9	356						
June 9	357						
June 9	358						
June 9	359						
June 9	360						
June 9	361						
June 9	362						
June 9	363						
June 9	364						
June 9	365						
June 9	366						
June 9	367						
June 9	368						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		The attached blue prints show the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. The gun was cocked. The dust used was burnt sand from the proof butts; the passage of projectiles through this sand converts it into something similar to clay in appearance but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry, and answered well for this purpose.
	Block opened at first attempt, but firing pin twice failed to explode primer. At the third attempt it fired all right.	
	The mechanism was not cleaned at all; neither oil nor water was used on it. The dust was not removed from the bore. The main bolt binds slightly. Still serviceable, and comparatively easy to work. Taken to machine shop and found slightly bent near the middle of its length. Straightened and replaced.	
		The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable.
		One blue print shows the apparatus at work; the other shows it at rest.
		After being dusted the gun was remounted and the time to open the breechblock and fire five rounds was noted. Time, 3 minutes 20 seconds.

ity at 1-mile target.]

Wind from right and rear, 20°, 11 miles an hour; barometer, 30.12; thermometer, 76°; humidity, 66.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	Struck 25 yards in front of target and ricochetted through 4 feet below and 1 foot left of center.	
	Struck target 7 feet below and 1½ feet left of center.	Open sight used.
	Struck 25 yards in front and ricochetted through 5½ feet below and 3 feet left of center.	Aimed at the upper left corner.
	Struck 9 feet below and one-half foot left of center on target.	Elevation by sight 1,700 yards.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	7	.....	3	.....	6.15	.....	2
1	.....	6	.....	1.85	.....	7	.....
5	.....	3	.....	5.85	.....	4	.....
2.5	.....	1	.....	3.35	.....	2	.....
0		.....	8	0.85	.....	.....	7
.....	1	0.5	.....	.....	0.15	1.5	.....
.....	2	.....	1	.....	1.15	.....	0
6	.....	.....	3	6.85	.....	.....	2
.....	5.5	.....	3	.....	4.65	.....	2
.....	7.5	.....	2.5	.....	6.65	.....	1.5

Center of impact—	Feet.
Below	0.85
Left	1
Mean vertical deviation from center of impact	3.75
Mean horizontal deviation from center of impact	2.9
Mean deviation from center of impact	4.74

Time to fire 10 rounds, 1 minute 36½ seconds.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weig

[For accuracy with rapidity at two 500-yard targets pla

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 11	369					2½	
June 11	370					2½	
June 11	371						
June 11	372						
June 11	373						
June 11	374						
June 11	376						
June 11	378						
June 11	380						
June 11	382						
June 11	384						
June 11	386						
June 11	388						
June 11	390						
June 11	392						
June 11	375						
June 11	377						
June 11	379						
June 11	381						
June 11	383						
June 11	385						
June 11	387						
June 11	389						
June 11	391						
June 11	393						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

80 feet apart, alternating shot by shot on the two targets.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 60°, 14 miles an hour; barometer, 30.22; thermometer, 89°; humidity, 49.	Fired at No. 1 target. Sight set at 480 yards. Struck 30 yards in front. Fired at No. 1 target. Sight set at 500 yards. Struck 22 yards in front and ricochetted through 1½ inches below and 3 inches left of center. Fired at No. 1 target. Sight set at 600 yards. Struck target 4½ feet below and 2½ feet left of center. Fired at No. 1 target. Sight set at 610 yards. Struck target 4 feet 5 inches below and 0.75 foot left of center. Fired at No. 2 target. Sight set at 610 yards. Struck target 1.75 feet below and 1 foot left of center.	Recoil very severe. Aimed at bull's-eye

TARGET No. 1.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
3	.....	...	5.5	5.425	.....	.....	2.725
...	1.5	...	4.5	0.925	.....	.....	1.725
...	0.75	...	4	1.675	.....	.....	1.225
...	4.5	...	2.5	.....	2.075	0.275	.....
...	3.75	...	2	.....	1.825	0.775	.....
...	3.5	...	2.75	.....	1.075	0.025	.....
...	3.25	...	2.5	.....	0.825	0.275	.....
...	2	...	1.5	0.425	.....	1.275	.....
...	4.5	...	1	.....	2.075	1.775	.....
...	3.5	...	1.5	.....	1.075	1.275	.....

Center of impact—	Feet.
Below	2.425
Left	2.775
Mean vertical deviation from center of impact	1.69
Mean horizontal deviation from center of impact	1.135
Mean deviation from center of impact	2.036

TARGET No. 2.

...	1.5	...	2.5	.....	0.24	0.229	.....
...	2	...	2	.....	0.74	0.729	.....
...	2.08	...	2.08	.....	0.82	0.649	.....
...	3	...	2.5	.....	1.74	0.229	.....
...	2.75	...	3.5	.....	1.49	.....	0.771
...	3.75	...	3	.....	2.49	.....	0.271
3	.....	...	1.5	4.26	.....	1.229	.....
2	.....	...	4.75	3.26	.....	.....	2.021

Center of impact—	Feet.
Below	1.26
Left	2.729
Mean vertical deviation from center of impact	1.50
Mean horizontal deviation from center of impact	0.612
Mean deviation from center of impact	1.624

Deflected by hitting an oak telegraph pole directly in line with the target, and are wholly omitted from the plotted target.

Time to fire the 20 rounds, 2 minutes 59⅘ seconds.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weigh

[Elsewhere

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 12	394						
June 12	395						
June 12	396						
June 12	397						
June 12	398						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	The blowbacks were secured by unloading the requisite number of rounds, decapping the cases and thinning the metal of the primers. The cases were recapped and the charges replaced.	
	The first and second blowbacks caused no delay save what was necessary to aim the gun on the butt.	
	Third blowback. The primer failed at least half a dozen times, and three or four of these times the long lanyard broke and had to be tied. A service cartridge procured from No. 6 magazine was fired at the first attempt, showing the mechanism in order. Time, 6 minutes 25 seconds. Another case ordered prepared for the third blowback. The firing pin was tapped with a mallet once or twice after the second failure to explode the third blowback. The primer was found well indented. The 6 minutes and 25 seconds comprise the whole time involved, including getting and firing the service cartridge.	
	After three-fourths of an hour the third blowback was ready and was fired at first attempt.	
	Service cartridge. It required three attempts to fire it. The 3 blowbacks blew out the primers and there was plenty of gas escaped into the mechanism. Time to fire 2 blowbacks and 1 service, 6 minutes 25 seconds; time to fire third blowback and 1 service, 33½ seconds; total time, 6 minutes 58½ seconds.	

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Rapidity with accuracy

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		By sight, yards.	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
June 13	399	1,000			2		
June 13	400	900			2		
June 13	401	1,000			2		
June 13	402	950			2		
June 13	403	1,100			1		
June 13	404	1,100			1		
June 13	405	1,110			½		
June 13	406						
June 13	407						
June 13	408						
June 13	409						
June 13	410						
June 13	411						
June 13	412						
June 13	413						
June 13	414						
June 13	415						

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786 pounds, at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

at 1,000 yards.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind front and left, 80°, 7 miles an hour; barometer, 30.25; thermometer, 63°; humidity, 74.	Miss; reported as having struck beyond target. Struck short. Struck short; reported over. Struck short. Struck short. Struck short; ricochetted through 6 feet below and 8 feet 2 inches right of center. Struck 3 feet below and 4 feet right of center.	Aimed at the top edge of bull's-eye. Smoke interfered. Recoil amounts to too much of a shock; punishment to use the present shoulder bar.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
...	2.5	4.5	....	0.675	.....	4.175	.....
...	1	3	....	2.175	.....	2.675	.....
...	1.5	3	....	1.675	.....	2.675	.....
...	1.5	0.5	....	1.675	.....	0.175	.....
...	6.5	0.75	....	.....	3.325	0.425	.....
...	5.5	0.5	....	.....	2.325	0.175	.....
...	2	.....	1	1.175	.....	.....	1.325
...	2.5	.....	1.5	0.675	.....	.....	1.825
...	4.25	.....	2.5	.....	1.075	.....	2.825
...	4.5	.....	4	.....	1.325	.....	4.325

	Feet.
Center of impact—	
Below	3.175
Right	0.325
Mean vertical deviation from center of impact	1.61
Mean horizontal deviation from center of impact	2.06
Mean deviation from center of impact	2.615

Time to fire 10 rounds, 2 minutes 10½ seconds.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[For rapidity with accuracy at 500 and 1,000 yard targets

Date.	No. of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*	*Inches.*
June 15	416	11 00			1		
June 15	417	6 00			0		
June 15	418	6 00			1		
June 15	419	5 00			0		
June 15	420	5 00			0		
June 15	421	7 00			0		
June 15	423						
June 15	425						
June 15	427						
June 15	429						
June 15	431						
June 15	433						
June 15	435						
June 15	437						
June 15	439						
June 15	441						
June 15	422						
June 15	424						
June 15	426						
June 15	428						
June 15	430						
June 15	432						
June 15	434						
June 15	436						
June 15	438						
June 15	440						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 23, 1894—Continued.

on same line, alternating shot by shot on targets.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 45°, 10 miles an hour; barometer, 30.22; thermometer, 83°; humidity, 43.	Fired at 1,000-yard target. Struck 4 feet 8 inches below and 2½ feet right of center. Fired at 500-yard target. Miss; over..... Fired at 500-yard target. Miss; over..... Fired at 500-yard target. Struck 10 yards in front of target, ricochetted through 2 feet above and 2 feet 6 inches right of center. Fired at 500-yard target. Struck 40 feet in front of target, ricochetted through 1 foot 7½ inches below and 8 inches left of center. Fired at 500-yard target. Struck 3 feet below and 2 feet 8 inches left of center.	Aimed at the upper left corner (1,000 yards). Aimed at bull's-eye (500 yards). Sight adjusted for each shot at each target. Round 432, lanyard broke causing a delay of 3 minutes. Deducted.

TARGET 1,000 YARDS.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
0		1.833	.....	1.633	.....	4.200	.....
.....	1.333	1.667	.....	0.300	.....	4.134	.....
.....	3.333	.....	2.167	.....	1.700	0.300	.....
.....	4.667	.....	2	.....	3.034	0.467	.....
.....	2	.....	3.5	.....	0.867	.....	1.033
.....	1.5	.....	4	0.133	.....	.....	1.533
.....	2.5	.....	5.5	.....	0.867	.....	3.033
.....	3	.....	5.5	.....	1.367	.....	3.033
1	.....	.....	4	2.633	.....	.....	1.533
1	.....	.....	1.5	2.633	.....	0.967	.....

Center of impact—	Feet.
Below	1.633
Left	2.467
Mean vertical deviation from center of impact	1.467
Mean horizontal deviation from center of impact	2.033
Mean deviation from center of impact	2.507

TARGET 500 YARDS.

.....	3	.....	2	.....	2.008	1.038	.....
.....	3.25	.....	2	.....	2.258	1.038	.....
.....	3.5	.....	4	.....	2.508	.....	0.963
.....	1.75	.....	4.125	.....	0.758	.....	1.088
.....	1.5	.....	3.5	.....	0.508	.....	0.463
.....	1.75	.....	4.417	.....	0.758	.....	1.380
.....	0.5	.....	4.75	0.492	.....	.....	1.713
.....	2.167	0.167	.....	.....	1.175	3.205	.....
3.75	.....	.....	2.75	4.742	.....	0.288	.....
3.75	.....	.....	3	4.742	.....	0.038	.....

Center of impact—	Feet.
Below	0.992
Left	3.038
Mean vertical deviation from center of impact	1.995
Mean horizontal deviation from center of impact	1.121
Mean deviation from center of impact	2.288

Time to fire the 20 rounds, 5 minutes 27½ seconds.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Second

Date.	No of fire.	Elevation.	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 21	442 to 446						

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786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

dust test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		Owing to the lack of uniformity in the conditions of the different breech mechanisms when subjected to the first dust test, it was considered advisable to repeat this test. In the second dust test all the parts of the different mechanisms were thoroughly washed with hot water and soap; they were then carefully dried and lightly oiled. When subjected to the blast of dust the gun was not cocked. The arrangement for dusting and the material used were the same as in the first dust test. The gun was subjected to a blast of dust for 8 minutes. The block opened without difficulty by 1 man, and the 5 rounds were fired with very little trouble. The bore was not wiped out. No oil or water used on block. Time to open block and fire 5 rounds, 55½ seconds. Before rusting, the breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap.

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Record of firing with Driggs-Schroeder 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[Rust

Date.	No. of fire.	Elevation	Instrumental velocity 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points, right.	Recoil.	Counter recoil.
			Feet.	*Pounds.*		*Inches.*	*Inches.*
June 26							
June 28	447 to 451						

786 pounds), at Sandy Hook Proving Ground, from May 2 to June 28, 1894—Continued.

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		Gun not cocked. Handle and rear sight removed. Screws holding sight in place replaced to prevent rust from getting into holes. Before immersing, a soft wood plug wrapped with a piece of cartridge bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber. The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical, and was lowered into the solution just enough to cover the breech mechanism.
		Gun immersed at 2:20 o'clock, June 26; gun taken out at 2:45 o'clock. Gun in solution 25 minutes.
		Gun allowed to stand undisturbed till 2:38 p. m., June 28, 1894, at which time the operation of opening the breechblock was begun.
		The breechblock could not be opened by hand nor by using a wooden mallet on the handle. At the end of 1½ minutes oil was used to soften the rust and the effort to open the block was continued. After 10 minutes, having failed to open the block, the main bolt was driven out and a copper drift was used on the block to jar it loose from its seat. At the end of 25 minutes the breechblock was out of the gun. The breech mechanism was then dismantled and all the parts wiped and oiled. The parts were well rusted, and, as a rule, a copper drift had to be used to separate them one from another. After being oiled the mechanism was assembled and replaced in the gun, the time consumed up to this point being 1 hour and 5 minutes.
		Five service rounds were then fired as rapidly as practicable.

	Hours.	Minutes.	Seconds.
Operation completed ...	3	46	4.5
Operation commenced ..	2	38	0.0
Time elapsed.....	1	8	4.5

Firing conducted in the presence of the Ordnance Board. Present: Maj. F. H. Phipps, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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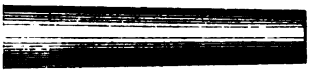

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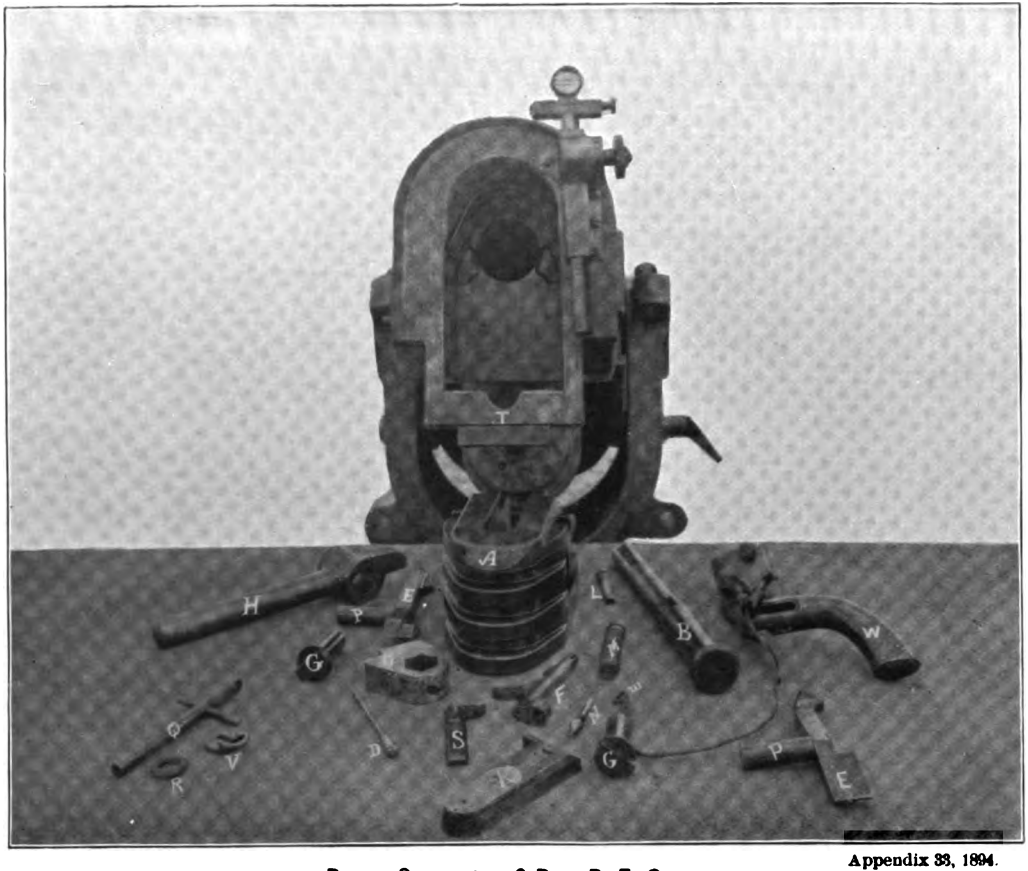

Appendix 33, 1894.

DRIGGS-SCHROEDER 6 PDR. R. F. GUN.

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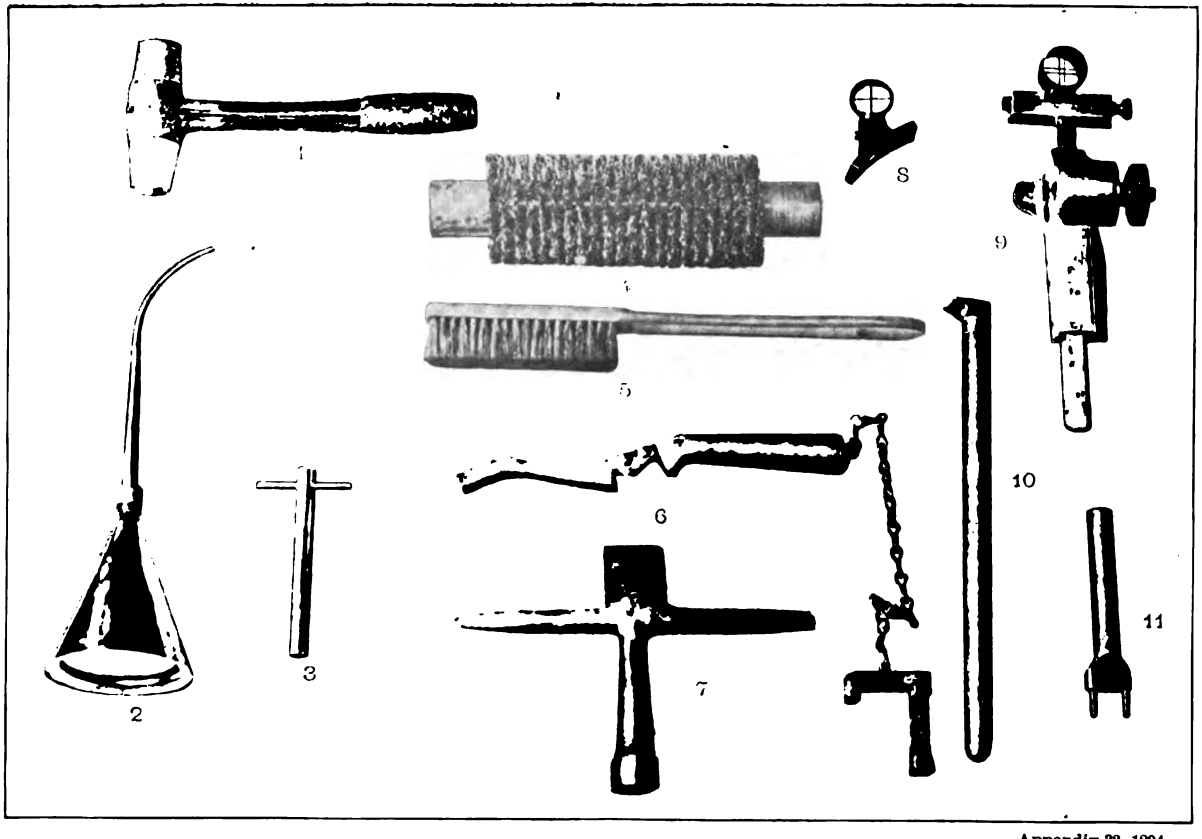

SIGHTS AND ACCESSORIES.

Appendix 33, 1894.

1. Babbitt mallet. 2. Oil can. 3. Firing-pin wrench. 4. Sponge brush. 5. Cleaning brush. 6. Block support. 7. Combination screw-driver. 8. Front sight. 9. Rear sight. 10. Hand extractor. 11. Face-plate drift.

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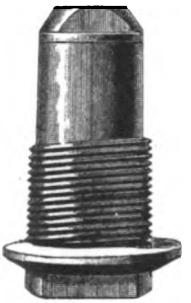
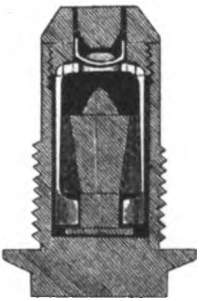
PLATE V.

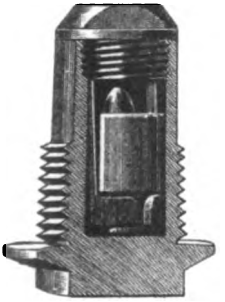
DRIGGS PERCUSSION FUZE.



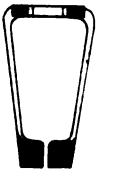
Positionof Spring before and during firing.



Position of Spring during flight.



Plunger.



Spring.

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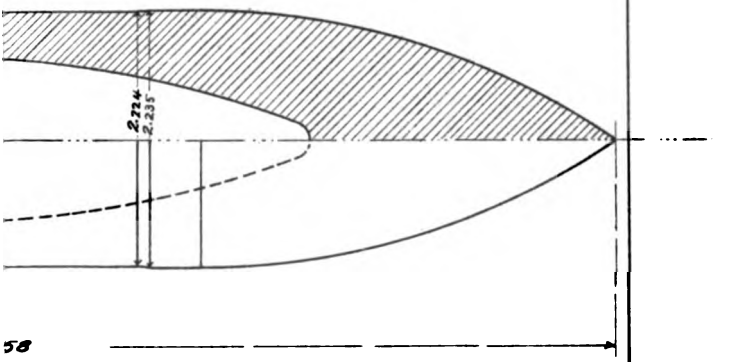

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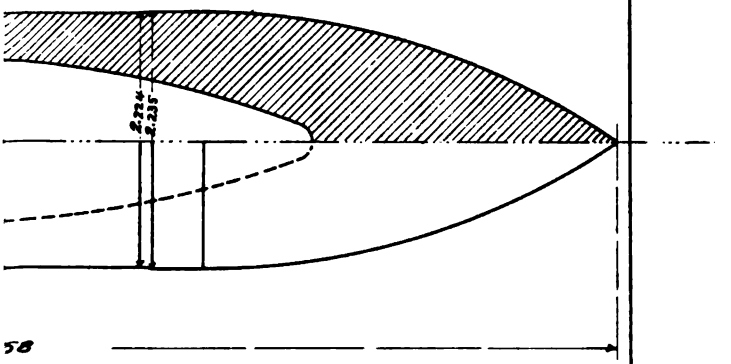

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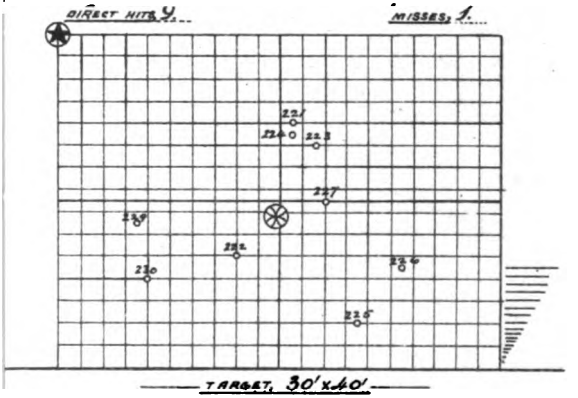
GUN.———

TARGET 3000 YARDS FROM GUN. MAY 14TH 1894.

DIRECT HITS 4. MISSES 1.



ROUND No.	MILES PER HOUR.	DIRECTION.
221	8	Right Rear 20°
222	"	" " "
223	9	" " 10°
224	"	" " "
225	10	" " "
226	"	" " "
227	12	Left Rear 20°
228	"	" " "
229	"	" " "
230	"	" " "

MEAN VE 5'.28.

" HE 6'.3.

" DI 8'.22.

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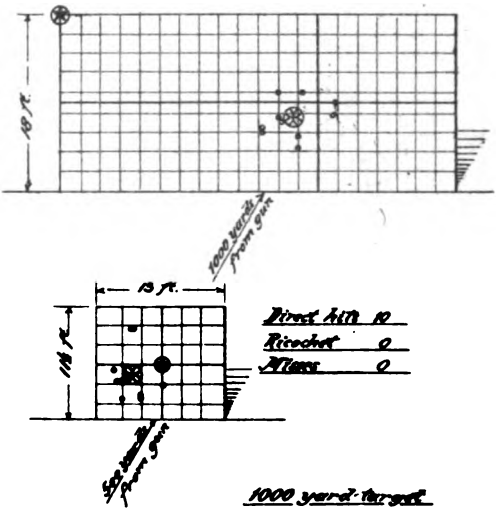
Alternating shot by shot on targets

June 16/94 Rounds 421 to 440 inclusive

Direct hits 10. Ricochet 0. Misses 0.



2.00 ft.	1.47 ft.
1.12 ft.	2.03 ft.
2.29 ft.	2.51 ft.

20 rounds = 5 m. 27½ sec.

10 miles per hour, from right and rear 45°

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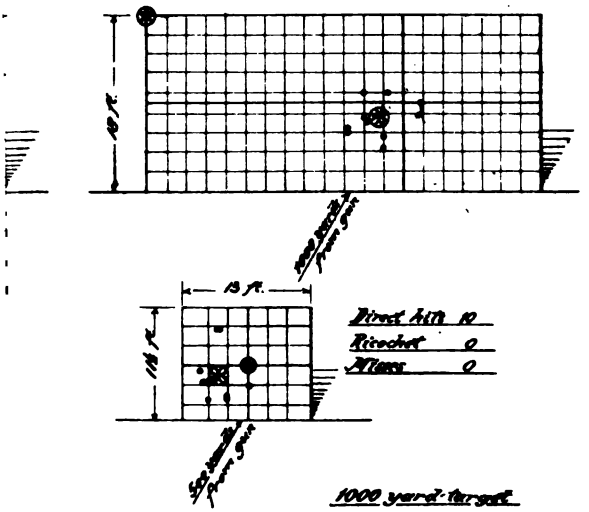
Alternating shot by shot on targets

June 15th Rounds 421 to 440 inclusive

Direct hits 10. Ricochet 0. Misses 0.



1000 yards target.

2.00 ft.	1.47 ft.
1.12 ft.	2.03 ft.
2.29 ft.	2.51 ft.

20 rounds = 5 m. 27½ sec.

10 miles per hour, from right and rear 45°

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APPENDIX 33 A.

TEST OF 6-POUNDER SPONSEL RAPID-FIRE GUN.

(3 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
GOVERNORS ISLAND, NEW YORK HARBOR,
New York City, October 9, 1894.

SIR: The following report of a 6-pounder Sponsel rapid-fire gun is respectfully submitted:

DESCRIPTION.

The cannon consists of a barrel united to or formed integral with the enlarged breech piece, which is divided to form the two sides, between which is located the vertically movable breechblock. On the inner sides of said sides respectively are formed the grooves or recesses for receiving the correspondingly formed projections or ribs of said sliding block. Said grooves are formed somewhat inclined to the vertical, so that as the block is slid down it is carried rearwardly a short distance, thus relieving the pressure against the head of the cartridge in the chambers. The vertical movements of the breechblock are accomplished by means of a lever operated by hand in a plane at right angles to the axis of the gun, which is fixed to the outer end of the crank shaft and held in place by the crank spring. The crank shaft has a bearing in the lower part of the breechblock and is retained in working position by the crank retainer, which fits in lower surface of breechblock. The inner end of the crank has an arm, on which is a stud turned to play in the crank cam, which is in the lower part of the breech. A recess is formed in the lower part of the front face of said block to allow the crank to turn and operate the block. There is also another recess in the lower part of the front face that is shaped like the arm on the crank shaft. It has clearance of 0 .01 inch around and about one-sixteenth inch from cam. This is only used when the block is to be removed.

The block is lowered by turning the lever to the right and downward, and during said turning of the lever the stud has passed to the left in the cam slot and returned again to the right. When the movement of the lever is reversed the breechblock is moved upward, and the breech of the gun is again closed.

The shell remaining in the chamber after a discharge is ejected during the downward movement of the breechblock by means of the two extractors, which slide horizontally in the grooves (grooves that are formed in the upper right and left hand sides of the breechblock).

After a discharge has taken place the breechblock is lowered as above described, and the extractors are carried down with it until the hook ends thereof have engaged the shell, when on the further downward movement of the breech block the above-described lugs pass into

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the lower and angular portion of the cam grooves and are thereby suddenly retracted to throw out the shells. For proper coaction with the extractors the breechblock is hollowed out at the top so as to form a trough, which trough is inclined so that the cartridge shell may begin to withdraw from the bore before the lower surface of said trough comes into alignment with said bore. To reload the cannon the operator inserts a cartridge into the chamber of the gun, pushing it in as far as possible or until the flange thereof comes in contact with the hook ends of the extractors. The breechblock now being raised, the angular forward part of the trough engages said cartridge head, and after the manner of a wedge forces the cartridge forward, following closely the forward or return movement of the extractors. The final forcing home of the cartridge is accomplished by the forward movement of the breechblock, due to the inclination of its guide bearers, as before set forth.

The firing pin is fitted to move longitudinally in the breechblock, and consists of the stem being flatted on both sides for a portion of its length and having an opening therein to receive the upper end of the cocking lever. A notch is formed on both sides of pin, the shoulders of said notch engaging with the sear.

The sear is also notched to form the detent pivot to engage the detent face of the firing pin. When the gun is cocked the sear is carried in the bore of the breechblock.

DISENGAGING THE SEAR FROM FIRING PIN.

A sear-spring plunger is provided, which stands in the recess which is formed for the same in the left-hand side of the breechblock and is pivotally connected to the sear by the ears that are formed on said sear. The plunger has a flange against which one end of the sear spring bears.

The sear-spring plunger is also pivotally connected with the trigger by the ears on sear, and is supported by a hole in the breechblock.

By means of the trigger on sear-spring plunger the cocking lever is disengaged from the firing pin, allowing said pin to be thrown forward to discharge the cartridge.

The cocking lever is carried on the rock shaft, which is fitted to work freely in a hole in breechblock prepared for the same, and said shaft has an arm formed on one end thereof, against which the mainspring plunger bears, said plunger having a notch in which arm of rock shaft engages, holding both in place in recess on right side of breechblock.

ACTION OF MECHANISM.

The gun having been fired, the action of the mechanism is as follows:

The breech is opened by pulling the lever to the right. A cam is formed on the crank shaft which carries the cocking lever and releases the firing pin from the primer before the block starts to descend. This being done, the block is lowered by the crank arm working in the crank cam. The extractors are carried in the block, where they come in contact with the shell. They have a powerful leverage to start the shell from its seat. When the cartridge head is unmasked the extractors take a quick motion to the rear, which throws the cartridge case well clear of the gun. The block at this point is brought to a stop by the extractors bringing up on a seat provided in the extractor cams. The cocking is done while the block is in its downward motion. The

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cam formed on the crank carries the cocking lever outward, carrying with it the firing pin. When this is withdrawn the distance of a notch the sear drops in the notch in the firing pin, and the arm on the rock shaft working in the mainspring plunger compresses the mainspring.

The gun is then ready for loading.

The new charge, having been entered in the chamber, is pushed home by hand until the head of the case comes against the hook of the extractors. The breechblock is closed by a reverse motion of the crank. As the block rises its inclined upper corners push the cartridge home, carrying with it the extractors. When the block is entirely up the face bears tightly against the head of the cartridge. The crank having passed a vertical position secures the block and is ready to fire. It is impossible to fire the gun before the block is home. First, the pin is not in line with the primer; and, second, the cam on the crank shaft will catch on the cocking lever before the pin can touch the primer. It is impossible to bring a shock on the primer in closing the breech, as the face of the block slides along the head of the cartridge, thus giving perfect safety in loading.

All parts being hardened, causes less friction and will wear much longer.

DIRECTIONS FOR DISMANTLING AND ASSEMBLING THE MECHANISM.

To remove the breechblock from the gun.—The breech being open after firing, press down with the right thumb and pull back on lever. The block is then ready to be removed.

To dismount mechanism after block is removed.—Stand the block on its upper end, lever toward operator; push in crank and lower lever with left hand; at the same time press on sear-spring plunger with the right thumb; this operation relieves tension on main and sear springs. Press the sear-spring plunger with the right thumb, push out the sear with the left, press down on mainspring plunger and pull out rock shaft. The mainspring, trigger, cocking lever, and firing pin are now released and can be taken out in order named. To disconnect the lever from the crank, throw off spring and pull out.

To assemble, proceed in the reverse order.

It is to be noted at this point that every piece of the breech mechanism is removed without the use of a tool of any kind; also the crank cam and extractor cam are removed by the hands.

NOMENCLATURE OF BREECH MECHANISM (PLATE I.)

1. Breechblock.
2. Operating crank.
3. Crank shaft.
4. Crank cam.
5. Two extractors.
6. Two extractor cams.
7. Firing pin.
8. Mainspring.
9. Mainspring plunger.
10. Cocking lever.
11. Rock shaft.
12. Sear.
13. Sear-spring plunger.
14. Trigger.
15. Sear spring.
16. Crank spring.
17. Crank retainer.

AMMUNITION.

The ammunition used in the test of this gun was purchased by the Department under contract with the Driggs Ordnance Company, and is fully described in the report of the test of the Driggs-Schroeder 6-pounder rapid-fire gun.

The following programme was adopted for the test:

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The gun to be carefully examined by the board. The number of parts in the breech mechanism, their strength, simplicity, and certainty of action to be noted, also the ease, safety, and certainty of the breech mechanism as a whole. Note especially the action of the firing pin and extractor, and the maximum outward position of the cartridge when it can be pushed home by the breechblock. During this examination 50 rounds to be fired at will.

VELOCITY.

Five rounds to be fired for velocity with full charges.

ACCURACY.

Ten rounds to be fired at each range of 1,000 yards, 1 mile, and 3,000 yards, the same conditions of aiming being repeated at each round, and the mean deviations determined.

RAPIDITY.

Determine number of rounds that can be fired in 5 seconds, 3 trials; also number of rounds that can be fired in 1 minute, 3 minutes, and 5 minutes, respectively, and finally the time required to fire 100 rounds, noting carefully during the firing, and especially at the end of each 25 rounds, the condition of the gun as regards heat, and ease, and certainty of action.

Two detachments of men, alternating every 25 or 50 rounds, as may be thought advisable.

RAPIDITY WITH ACCURACY.

Fire 10 aimed shots as rapidly as possible at the 1,000 yards and 1 mile targets. Also 10 aimed shots at targets in same line and ranges of 500 and 1,000 yards alternately; also 10 aimed shots alternately at targets at about 500 yards range, placed about 75 feet apart.

DUST.

The mechanism to be exposed to a blast of fine dust in such manner as to insure its being uniformly and equally covered with the dust, after which 20 rounds to be fired as rapidly as possible.

EXCESSIVE CHARGES.

The gun to be fired with 5 charges giving gradually increasing pressures up to 45,000 pounds per square inch, if such pressures are attainable.

DEFECTIVE CARTRIDGES.

The gun to be tested with defective cartridges in the same manner as is usual in the trial of small arms.

Any rounds that may remain after the above tests to be expended in such manner as may be deemed best by the board as a result of the circumstances developed; the last 5 rounds to be fired after the mechanism of the gun has been rusted in a thorough and uniform manner.

The test, in accordance with the programme, was commenced on May 1 last.

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The length of the gun from the seat of the head of cartridge case to the muzzle is 45 calibers. The gun is fired either by a lanyard or by pressing a push button on the face of the breech. The latter method is objectionable because of bringing the forearm of the operator in direct opposition to the recoil.

The action of the mechanism in manipulation and deliberate firing was found to be satisfactory, except that the lanyard was not of sufficiently strong material and broke several times. Although the piece can not be fired before the breech is closed, the sear can be disengaged, necessitating recocking by opening the breech. Three men efficiently serve the piece, one to pass ammunition, one to load and handle the block, and one to aim and fire. The block seems to have no tendency to fly open upon firing. The cartridge can be pushed home by the block in closing, when at a distance of 1¼ inches from its seat. The sight furnished with the gun was not entirely satisfactory, having no provision for fastening the drift scale, and the clamping arrangement failing to prevent the sight from rising slightly at each shot. Closing the breechblock disturbs the aim, both in direction and elevation.

Starting with the breechblock closed, the mechanism was removed and dismantled by one man (the representative of the gun) in 48½ seconds. It was replaced and the motion of firing executed in 1 minute 44⅛ seconds. No tools were used. A test was made of the time required to fire one shot, remove and replace the mainspring, sear spring, firing pin, and extractor, these being the parts most liable to injury in action, and then to fire a second shot. The time between the two shots was 1 minute 12⅞ seconds.

The weight of the breech mechanism complete, including the extractors and handle, is 59 pounds, and the number of its parts 19.

VELOCITY.

The maximum velocity obtained in firing 5 rounds was 1,836 foot-seconds; the minimum, 1,822 foot-seconds, and the mean, 1,828 foot-seconds.

ACCURACY

At 1,000 yards range the mean vertical deviation from the center of impact of 10 shots was 1.27 feet, the mean horizontal deviation 1.4 feet, and the mean deviation 1.89 feet. Three sighting shots were used, and there were no misses.

At 1 mile range there were 5 sighting shots and 10 shots at the target, of which all were hits, the deviations being: Mean vertical, 3.56 feet; mean horizontal, 2.56 feet; mean, 4.38 feet.

At 3,000 yards range there were 3 sighting shots and 10 shots at the target, of which 4 were misses. The deviations of the 6 hits were: Mean vertical, 5.83 feet; mean horizontal, 3.50 feet; mean, 6.80 feet.

At a second attempt to make a target at the same range, 16 shots were fired, when the attempt was given up owing to a high wind from the right and rear.

The targets are represented on Pl. II.

RAPIDITY.

The number of rounds fired in 5 seconds was: At the first trial, 3; at the second trial, 3; at the third trial, 2.

The number of rounds fired in 1 minute was 24, and in 3 minutes 73. The 24 rounds were fired in the first minute of the 3-minute test. The

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officers loading and firing exchanged places at the end of 1½ minutes.

One hundred rounds were fired in 4 minutes 56⅘ seconds. The ammunition was placed on a table in rear of the piece, and close to it. Three persons, 2 officers and 1 enlisted man, were employed in the service, the officers loading and firing exchanging places after each 25 rounds.

The mechanism worked satisfactorily throughout. After the firing soft solder would melt when placed anywhere along the chase; temperature, about 375° F.

RAPIDITY WITH ACCURACY.

In firing for rapidity with accuracy at 1,000 yards range, 3 sighting shots were used, then 10 shots at the target, of which 8 were hits, the deviations of these being: Mean vertical, 4.104 feet; mean horizontal, 1.52 feet; mean, 4.377 feet. The time required to fire the 10 shots, 2 minutes 12¼ seconds.

At 1 mile range 10 shots were fired at the target, of which 3 were misses. Of the 7 hits the deviations were: Mean vertical, 2.06 feet; mean horizontal, 2.06; mean, 2.91 feet. Time to fire the 10 shots, 1 minute 57¾ seconds.

At 2 targets at 500 yards range, placed 80 feet apart, 20 shots were fired, 10 at each, alternating at every shot. One sighting shot was used, and there were no misses for either target. The deviations were: Target No. 1, mean vertical, 1.09 feet; mean horizontal, .69 foot; mean, 1.25 feet. Target No. 2, mean vertical, .76 foot; mean horizontal, .65 foot; mean, 1 foot. Time for firing 20 rounds, 5 minutes 17½ seconds. The sight was adjusted for each shot.

Two sighting shots were made at each of the 2 targets, placed in the same line at ranges of 500 and 1,000 yards, followed by 10 shots at each target. There were no misses, and the deviations were: 500 yards target, mean vertical, 1.289 feet; mean horizontal, .858 foot; mean, 1.55 feet; 1,000-yards target, mean vertical, 2.28 feet; mean horizontal, 1.75 feet; mean, 2.88 feet. The 20 shots were fired in 5 minutes 24½ seconds. The sight was adjusted at each shot. A representation of the target is inclosed, Pl. III.

DUST.

Two tests were made of the effect of dust upon the mechanism. At the first test the gun was not cleaned after firing defective cartridges, care being taken to avoid removing residue from the mechanism in handling. The attached blue print shows the method adopted for dusting the mechanism. "A" is a lead pipe leading from the pine box "C" to the hand bellows in the blacksmith shop. The gun was cocked. The dust used was burnt sand from the proof butts. The passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry, and answered well for this purpose.

The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable.

One blue print shows the apparatus at work; the other shows it at rest.

After being dusted the gun was remounted, and the time to open the ech block and fire the 5 rounds was noted. Time, 7 minutes and 55 nds.

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In the second dust test all the parts of the different mechanism were thoroughly washed with hot water and soap. They were then carefully dried and lightly oiled.

When subjected to the blast of dust the gun was not cocked.

The arrangement for dusting and the material used were the same as in the first dust test.

The gun was subjected to a blast of dust for 8 minutes (and 5 seconds accidental).

Breech block opened without difficulty after being shaken a few times, and the 5 rounds were fired with very little trouble. Some waste was pushed through the bore once to remove dust from bore. No oil or water was used.

Time to open block and fire 5 rounds, 2 minutes 5¼ seconds.

Five rounds instead of 20 were fired after dusting because of scarcity of ammunition.

EXCESSIVE PRESSURES.

Twelve rounds were fired with excessive charges, the quantities of rifle powder added to produce excessive pressures, and the corresponding pressures obtained were as follows: One ounce, 36,900 pounds per square inch; 2 ounces, 40,089 pounds per square inch; 2¼ ounces, 44,182 pounds per square inch; 2½ ounces, 51,075 pounds per square inch; 2⅝ ounces, 47,111 pounds per square inch; 2⅝ ounces, 50,425 pounds per square inch; 2¾ ounces, 50,500 pounds per square inch; 3 ounces, 51,800 pounds per square inch; 3 ounces, 45,733 pounds per square inch; 3¼ ounces, 45,733 pounds per square inch; 4 ounces, 53,975 pounds per square inch; 4½ ounces, 47,250 pounds per square inch. After each round the breechblock opened easily and no damage was apparent.

DEFECTIVE AMMUNITION.

Defective cartridges, prepared in three ways, were used. In the first the cartridge case was prepared by filing obliquely through the edge of the rim so as to just show an opening to the interior at the junction of the head and wall. The slots are at the extremities of two diameters at right angles with each other.

The cartridge was placed in the gun so that the solid part of the rim came opposite the extractors.

There was quite an escape of gas as a matter of course. The breechblock could not be opened by hand at all, and it required considerable sledging, after the addition of oil, to open it. Once open it could not be closed by hand at all and it was sledged up till it projected well above the top surface of the gun, and the residue was wiped off.

In all it required about three-fourths of an hour to get ready to fire the next round.

The next cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other and each was halfway between the primer and the rim.

The breechblock was opened more easily than in the previous round but could not be moved by hand. The sledge had to be used as before.

A service cartridge was fired at the first attempt, showing all parts in working condition. The breechblock opened easily.

Blow backs were obtained by unloading the requisite number of rounds, decapping the shells, and thinning the metal of the primers. The shells were recapped and the charges replaced.

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With the second blow back tried, four attempts failed to explode the primer, due to the firing pin being fouled by residue from previous round. The cartridge was removed, and the firing pin was tapped gently with a wooden mallet. Replacing the cartridge, it was fired successfully at the next attempt.

With the third blow back, one attempt failed to explode the primer. The cartridge was removed, and the firing pin tapped as in the previous round. This failed to show the point of the pin, and snapping also failed. The block was then dismounted, and the firing pin was found broken in three pieces. The point remained in the face of the block, being held by the residue, and was removed with some difficulty. The residue was removed sufficiently to permit the insertion of a new firing pin. The crank shaft was removed, and the residue wiped from it. The mechanism was replaced, and the third blow back fired at the first attempt.

With a service cartridge two attempts then failed to explode the primer. The firing pin was tapped with mallet to force it through surrounding residue. The mechanism was cocked again, and the cartridge fired at the first attempt.

Total time of firing three blow backs and one service round, 26 minutes and 14 seconds.

RUST.

Gun not cocked.

The breech mechanism was dismantled and thoroughly cleaned by washing in hot water and soap preparatory to rusting. The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical and was lowered into the solution just enough to cover the breech mechanism. Before immersing a soft-wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber.

The sight seat and the hole for spring-locking pin were filled with waste and putty. The depressions at the outer ends of the pins on the extractor cams were also filled with putty.

The gun was in the solution twenty-five minutes.

The gun was allowed to rust for forty-eight hours. The block could not then be moved by hand nor by using a mallet on the handle. Oil was poured over the block from an oil can, at the same time using mallet on handle and sledge and copper drift on block to drive it down. This operation opened the block about halfway. The effort to open the block was continued until 5 p. m., but no further progress was made. The block was then closed in the same manner, well oiled, and left over night. Time, one hour forty minutes seven seconds.

On the following day the attempt to open the block was resumed, using oil, sledge, and copper drift. The gun was dismounted at 10:16 o'clock, after sledging on top of block and failing to move it. The gun was turned upside down and the sledging continued on bottom and top alternately, the gun being rolled over to correspond. In this manner the block was finally removed. The crank arm was found broken between the crank and the stud. The mechanism was dismantled and cleaned and burs dressed down by a machinist. The burs were in the bearing of the crank shaft, and were caused principally by spawls from the cocking lever. The mechanism, after being thoroughly cleaned and oiled, was assembled and placed in the gun. The cocking lever was so badly injured that the mechanism could not be operated, and the effort to fire the 5 rounds had to be abandoned. Total time, between seven and eight hours.

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It is probable that upon a second trial the manipulation, after rusting, would be more successful.

The only accidents which occurred previous to those mentioned under the rust test, were the breaking of the lanyard noted, and the breaking of the firing pin after the two hundred and seventy-fourth and at the three hundred and twenty-fifth round; the first time by snapping the lock with no cartridge in the gun; the second time during the firing of blow-back cartridges.

The loading and firing were done by Lieut. M. F. Harmon, First Artillery, and Lieut. F. P. Peck, Ordnance Department.

The following table shows a summary of the general results of the test, which was finished on June 15, 1894, 364 rounds being fired:

Weight.....pounds..	792
Caliber.....inches..	2.244
Length.....calibers..	45, scant.
Weight of breech mechanism.....pounds..	59
Number of parts of breech mechanism.....	19
Time to dismantle breech mechanism.....seconds..	48⅘
Time to assemble breech mechanism.....	1m 44⅘s
Distance from seat in chamber at which breechblock will force cartridge home.....inches..	1¼
Time to fire 1 round, change mainspring, searspring, firing pin, and extractor, and fire another round.....	1m 12⅘s
Time to fire 100 rounds.....	4m 56⅘s
Number of rounds fired in 1 minute.....	24
Number of rounds fired in 3 minutes.....	73
Number of rounds fired in 5 seconds, first trial.....	3
Number of rounds fired in 5 seconds, second trial.....	3
Number of rounds fired in 5 seconds, third trial.....	2
Time to fire 2 defective and 1 service cartridge (not noted accurately but exceeded 1 hour).	
Time to fire 5 rounds after dusting, first test.....	7m 55s
Time to fire 5 rounds after dusting, second test.....	2m 5¼s
Time required to fire 3 blow backs and 1 service cartridge.....	26m 14s
Time required to open breechblock and fire 5 rounds after rusting.....	7+h
Mean velocity, foot seconds.....	1,828

	Accuracy.			Accuracy with rapidity.		Alternating two 500 yards.		Alternating 500 and 1,000 yards.	
	1,000 yards.	1 mile.	3,000 yards.	1,000 yards.	1 mile.	No. 1.	No. 2.	500 yards.	1,000 yards.
Mean vertical deviation.....feet..	1.27	3.56	5.83	4.10	2.06	1.09	0.76	1.29	2.28
Mean horizontal deviation....do...	1.4	2.56	3.50	1.52	2.06	0.69	0.65	0.86	1.75
Mean deviation.....do...	1.89	4.38	6.80	4.38	2.91	1.25	1	1.55	2.88
Number of hits.....	10	10	6	8	7	10	10	10	10
Number of misses.....	0	0	4	2	3	0	0	0	0
Time to fire.....	.....	.....	.....	2m 12¼s	1m 57⅘s	.....	.....	.....	.....
Time to fire both targets.....	.....	.....	.....	.....	.....	5m 17⅘s		5m 24⅕s	

Firing record and three plates enclosed.

FRANK. H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3057)

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[Object of firing, test of

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
May 2	1		Before —1 18½ After —1 19				3½	
May 2	2		18 53				3¼	2¼
May 2	3		18 53				3¼	2¼
May 2	4		18 53				3¼	2¼
May 2	5		18 53				3¼	2¼
May 2	6		18 53				3¼	2¼
May 2	7		18 53				3¼	2¼
May 2	8							
May 2	9							
May 2	10							
May 2	11							
May 2	12							
May 2	13							
May 2	14							
May 2	15							
May 2	16							
May 2	17							

[To obtain

May 3	18		15 00					
May 3	19			1,832 1,834				
May 3	20			1,882 1,839				
May 3	21			1,830 1,825				
May 3	22			1,818 1,826				
May 3	23			1,824 1,824				
				50+$\frac{1}{16}$				

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894.

6-pounder rapid-fire gun.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....		Weight of breechblock and breech mechanism complete, including extractors and handle, 59 pounds. Length of gun from seat of head of cartridge case to muzzle, 45 calibers, scant.
		Starting with the breechblock closed the breech mechanism was removed and dismantled by 1 man (representing the gun) in 55 seconds, using no tools whatever save parts of mechanism. At the first trial two extractor cams and the crank cam were left in the gun. Upon being allowed a second trial the operation was completed in 48½ seconds, nothing forgotten.
		The breech mechanism of this gun consists of 19 pieces including the breechblock itself and the handle by which it is manipulated. The mechanism was assembled, replaced in the gun, and the motion of firing executed, all in 1 minute 44⅘ seconds.
.....	Fired into sand butt	
.....	Fired to sea at the extreme elevation. Counter recoil spring is not strong enough to return the piece back into battery at this elevation. It was 1½ inches from battery at the end of this group of 6 shots.	
.....	.....	
.....	.....	
.....	.....	
.....	Lanyard broke	
.....	.....	
.....	.....	
.....	Piece failed to cock. Several rounds were fired rapidly and this failure to cock was caused by holding the lanyard so taut while the block was being opened that the sear was prevented from engaging. It is impossible for the piece to fail to cock in any other way unless some part of the mechanism is missing or broken.	
.....		
.....		
.....		
		The time was taken by the proof officer, using a stop watch which reads to one-fifth of a second.
		Lieuts. Harmon, First Artillery, and Peck, Ordnance Department, did all the loading and firing.
		The gun is fired by means of a lanyard, or by pressing a push button on the base of the breech. As the latter method brings the forearm of the operator in direct opposition to the recoil, it is considered dangerous and has not been used; it is convenient in dismantling the mechanism.
		The breechblock will force the cartridge home when it is 1½ inches short of its seat in the chamber.
		The drift scale is connected to the bar of the rear sight by an easy fitting dovetail joint; it is set in position by taking hold of it and sliding it along, and there is no provision for fastening it in a given position. Clamping arrangement does not hold the sight from rising; it rises slightly at each shot.
		The lever for clamping the elevation does not have enough clearance from the shield lug, resulting in injury to the hand of the operator when using it hastily.
		Closing the breechblock disturbs the aim, both elevation and direction.

velocities.]

.....	Warming charge. Fired to sea	
.....	.....	
.....	.....	Before firing the rear edge of breechblock rounded off to prevent injury to the hand in loading.
.....	.....	Firing for velocity conducted by Lieut. M. F. Harmon, First Artillery.
.....	Fired into sand butt	Velocity taken by Lieut. F. P. Peck, Ordnance Department.
.....	.....	

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight

[To test gun for

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
May 7	24 to 124						After 100 rounds gun ½ inch from battery.	

[To test the accuracy

May 8	125	1,000			2			
May 8	126	900			2			
May 8	127	800			3			
May 8	128	900			3			
May 8	129							
May 8	130							
May 8	131							
May 8	132							
May 8	133							
May 8	134							
May 8	135							
May 8	136							
May 8	137							

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752 pounds) *at Sandy Hook Proving Ground May 2 to June 29, 1894*—Continued.

rapidity, 100 rounds.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Fired to note the place of striking	In firing for rapidity the ammunition was placed on a table in rear of the gun and as close to it as possible without interfering with the handling of the gun. Taking the ammunition from this table 3 men served the gun. Time required to fire 100 rounds, 4 minutes 56½ seconds. Lieuts. Harmon and Peck alternated in loading and firing, the changes being made at the end of each group of 25 shots. Rosin on gun 3 inches in rear of recoil sleeve melts at the thirty-fifth round. Soft solder melted anywhere along the barrel in front of the jacket when placed on the outside of the gun after the firing. Hard solder did not melt. Soft solder hardened on gun at the end of 16 minutes after firing ceased.

of gun at 1,000 yards.]

Wind from right and rear, 45°, 15 miles an hour; barometer, 29.87; thermometer, 71°; humidity, 58.

Fall of shot could not be located .....
Struck target 2 feet above and 3 feet right of center.
Struck target 7½ feet below and 2½ feet left of center,

Aimed at the upper left corner.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	2	.....	4.5	.....	1.55	.....	1.1
2	.....	.....	0.5	2.45	.....	2.9	.....
.....	1	.....	5	.....	.55	.....	1.6
.....	1	.....	3	.....	5.5	0.4	.....
3	.....	.....	1	3.45	.....	2.4	.....
0	.....	.....	3	.45	.....	0.4	.....
.....	1.5	.....	2.5	.....	1.05	.9	.....
.....	1.5	.....	4	.....	1.05	.....	.6
.....	1	.....	5	.....	.55	.....	1.6
.....	1.5	.....	5.5	.....	1.05	.....	2.1

Round 128, first shot to count on target

Center of impact—	Feet.
Below	0.45
Left	3.4
Mean vertical deviation from center of impact	1.27
Mean horizontal deviation from center of impact	1.4
Mean deviation from center of impact	1.89

Firing conducted by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[To test the accuracy

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Right.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			Quadrant. ° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
May 9	138	1,700	2 18		0			
May 9	139	1,600	2 44		1			
May 9	140	1,400	1 47		1			
May 9	141	1,500	1 56		1			
May 9	142	1,550	1 58		2			
May 9	143	1,600	2 5		3			
May 9	144	1,600	2 5		3			
May 9	145	1,600	2 5		3			
May 9	146	1,600	2 5		3			
May 9	147	1,600	2 5		3			
May 9	148	1,600	2 5		3			
May 9	149	1,600	2 5		3			
May 9	150	1,600	2 5		3			
May 9	151	1,600	2 5		3			
May 9	152	1,600	2 5		3			

[To test the accuracy

May 11	153	2,900	4 42		1			
May 11	154		4 42		1			
May 11	155		4 50		0			
May 11	156		4 47		0			
May 11	157		4 47		0			
May 11	158		4 47		0			
May 11	159		4 47		0			
May 11	160		4 47		0			
May 11	161		4 47		0			
May 11	162		4 47		0			
May 11	163		4 47		0			
May 11	164		4 47		0			
May 11	165		4 47		0			

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

of gun at 1 mile.]

Wind from right and rear, 30°, 9 miles an hour; barometer, 30.09; thermometer, 80°; humidity, 65.

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.

At discharge, the elevation increased 15 minutes and the drift scale moved slightly to the right. Shot struck 150 yards in rear.
Elevation increased 22 minutes, the drift scale moved 3 points right. Struck 125 yards beyond.
Struck 100 yards in front.
Struck 8 yards beyond and 6 feet to the left of left edge.
Struck 6 yards in front, and ricochetted through 11 feet below and 12 feet left of center.

General remarks.

Aimed at the upper left corner.
Clamping does not change either direction or elevation.
Rear sight graduated at 100-yard intervals and the stop only engages at those points; sight can only be set at even 100 yards.
Sight jumped up 100 yards each shot except rounds 149 and 150.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
1		0			1.05	2.2	
	3	0			5.05	2.2	
	1		4		3.05		1.8
5			4	2.95			1.8
	2	2			4.05	4.2	
4			4	1.95			1.8
12			3	0.95			0.8
	1		7		3.05		4.8
0.5			4		1.55		1.8
5		2		2.95		4.2	

Round 143 the first shot to count on target.

Center of impact—	Feet.
Above	2.05
Left	2.2
Mean vertical deviation from center of impact	3.56
Mean horizontal deviation from center of impact	2.56
Mean deviation from center of impact	4.38

of gun at 3,000 yards.]

Wind left and front, 55°, 10 miles an hour; barometer, 30.35; thermometer, 54°; humidity, 84.

Struck target 13 feet below, 8 feet right.
Struck target 13 feet below, 14 feet right.
Struck target 11 feet above, 1 foot left.

Aimed at the upper left corner.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
	7	0			13.17		3.17
5		6			1.17	2.83	
12			2	5.83			5.17
11		6		4.83		2.83	
3		1			3.17		2.17
13		8		6.83		4.83	

Round 156 the first shot to count on target.
Round 159 miss; struck 10 yards in front.
Round 160 miss; struck 40 yards in front.
Round 163 miss; struck 40 yards in front.
Round 165 miss; struck 1 foot in front.

Center of impact—	Feet.
Above	6.17
Right	3.17
Mean vertical deviation from center of impact	5.83
Mean horizontal deviation from center of impact	3.50
Mean deviation from center of impact	6.80

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[To test the accuracy of gun at

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity 125 feet from muzzle	Deflection points. *Right.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			Quadrant. ° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
May 15	166		4 45		3			
May 15	167		4 40		3			
May 15	168		4 30		4			
May 15	169		4 30		3½			
May 15	170		4 35		3¼			
May 15	171		4 33		3¼			
May 15	172		4 34		3¼			
May 15	173		4 34		3¼			
May 15	174		4 33		3¼			
May 15	175		4 30		3¼			
May 15	176		4 27		3			
May 15	177		4 29		3			
May 15	178		4 28½		3			
May 15	179		4 28½		3			
May 15	180		4 28½		3			
May 15	181		4 28½		3			

[To determine number of rounds that can be fired in 5 seconds, three trials; also

June 1	182 to 263							

[Excessive

June 6	264					4, 36,618		
June 6	265					4, 36,900		
June 6	266					4, 40,089		
June 6	267					4, 44,182		
June 6	268					4, 51,075		
June 6	269					4, 47,111		
June 6	270					4, 50,425		
June 6	271					4, 50,500		
June 6	272					4, 51,800		
June 7	273					4, 45,733		
June 7	274					4, 45,733		
June 7	275					4, 53,975		
June 7	276					4, 47,250		

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

3,000 yards; second attempt.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 30°; barometer, 29.98; thermometer, 68°; humidity, 55.	Struck 100 yards beyond	Target not visible; aimed at a board nailed to left edge and projecting above its top.
	Struck 75 yards beyond and on line	
	Struck target 6 feet left of center	
	Struck 35 yards in front and on line with right edge.	
	Struck target 12 feet above and 5 feet right of center.	
	Struck under target, 6 feet left of center	
	Struck target 16 feet above center	
	Struck 125 yards beyond	This range for this gun, sight only used for direction; target could not be seen, owing to intervening shrubbery.
	Struck 110 yards beyond	
	Struck target 15 feet above, 12 feet right of center.	
	Struck in front of target	Target not plotted.
	Struck target 11 feet above, 8 feet right of center.	
	Struck target 12 feet above, 6 feet left of center.	
	Struck target 2 feet above, 2 feet right of center.	
	Struck target 8 feet above, 16 feet right of center.	
	Struck 16 yards in rear and 10 feet right	

number of rounds that can be fired in 1 minute and 3 minutes, respectively.]

	182 fired to sea to note the place of striking.	In the firing of June 1 the arrangement of the ammunition and the number of men serving the piece were the same as in the 100-round test for rapidity.
	Number of rounds fired in 5 seconds:	
	First trial 3	
	Second trial 3	
	Third trial 2	
	Number of rounds fired in 1 minute 24	
	Number of rounds fired in 3 minutes 73	In the 3-minute test Lieuts. Harmon and Peck alternated in loading and firing, changing at the end of each 1.5 minutes.
	The number of rounds fired in 1 minute was determined by noting the number fired in the first minute of the 3-minute test.	

charges.]

	Service charge	Copper cylinders of 32,000 pounds initial compression and tables of 1892 used in rounds 264, 265, 266, 273, 274, and 276.
	1 ounce rifle powder added to charge	
	2 ounces rifle powder added to charge	
	2½ ounces rifle powder	
	2¾ ounces rifle powder, (made 2½ ounces at Mr. Bennett's suggestion)	
	2½ ounces rifle powder	
	2¾ ounces rifle powder. Gauge leaked. Breechblock opened easily	Copper cylinders of 40,000 pounds initial compression and tables of 1893 in rounds 267, 268, and 269.
	2¾ ounces rifle powder. Breechblock opened easily	
	3 ounces rifle powder. Breechblock opened easily	Copper cylinders of 50,000 pounds initial compression and tables of 1893 in rounds 270, 271, 272, and 275.
	3 ounces rifle powder. Breechblock opened easily and no leak of gas	Before round 275 a new firing pin put in.
	3¼ ounces rifle powder. Breechblock worked easily	Round 276, 4¼ ounces of rifle powder added to charge.
	4 ounces rifle powder	
	Block opened as before. Point of firing pin broken by snapping with no cartridge in gun.	

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[Test with defect

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 9	277							
June 9	278							
June 9	279							

[Dust

June 9	280							
June 9	281							
June 9	282							
June 9	283							
June 9	284							

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

ive cartridges.]

Wind. strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
....	The cartridge case was prepared by filing obliquely through the edge of the rim so as to just show an opening to the interior at the junction of the head and wall. The slots are at the extremities of two diameters at right angles with each other. Cartridge placed in the gun so that the solid part of the rim came opposite the extractors. There was quite an escape of gas as a matter of course. The breechblock could not be opened by hand at all and it required considerable sledging after the addition of oil to open it. Once open, it could not be closed by hand at all, and it was sledged up till it projected well above the top surface of the gun, and the residue was wiped off. In all it required about three-quarters of an hour to get ready to fire the next round.	
.....	The cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior; the slots were at right angles with each other and each was half way between the primer and the rim. Breechblock opened more easily than in round 277, but could not be moved by hand. The sledge had to be used as before.	
.....	Service cartridge. Fired at first attempt, showing all parts in working condition. The breechblock opened easily. The breechblock was then removed for convenience in handling the gun, and the gun taken to the blacksmith shop to be dusted without any part being cleaned in any degree. Care was exercised to avoid removing residue from the breech mechanism in handling the gun.	

test.]

.....	Block opened easily, but could not be closed by hand. Water was thrown over it to remove some of the dust and it could then be worked, but not easily.	The attached blue print shows the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. The gun was cocked. The dust used was burnt sand from the proof butts. The passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose.
.....	Block required four blows of a mallet on under side to close it for this round.	The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable.
		One blue print shows the apparatus at work; the other shows it at rest.
		After being dusted the gun was remounted and the time to open the breechblock and fire the 5 rounds was noted. Time, 7 minutes and 55 seconds.

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight

[To test gun for accuracy

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 9	285							
June 9	286							
June 9	287							
June 9	288							
June 9	289							
June 9	290							
June 9	291							
June 9	292							
June 9	293							
June 9	294							
June 9	295							
June 9	296							
June 9	297							
June 9	298							
June 9	299							
June 9	300							
June 9	301							

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7.52 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

with rapidity at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 30°, 11 miles an hour; barometer, 30.12; thermometer, 75°; humidity, 66.	Sighting shot, struck target 3 feet above and 3½ feet right of center.	

Above.	Below.	Right.	Left.
3		3.5	
	11	7.5	
	4	8	
	2.5	9	
	0.5	4	
7		7	

Six rounds fired in 1 minute 20 seconds, and firing suspended to allow ship to pass and a new target made from beginning.
Time required to fire 10 rounds, 1 minute 57⅞ seconds.
Aimed at the upper left corner of target.

TARGET.

From center of target				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
2		4.5		4.571			4.928
	1	9		1.571			0.428
	3	8			0.429		1.428
	3	11			0.429	1.572	
	3.5	9			0.929		0.428
	1.5	12		1.071		2.572	
	8	12.5			5.429	3.072	

Miss
Miss
Miss

Center of impact—	Feet.
Below	2.571
Right	9.428
Mean vertical deviation from center of impact	2.061
Mean horizontal deviation from center of impact	2.061
Mean deviation from center of impact	2.914

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber 2.244 inches; weight,

[For accuracy with rapidity at two 500-yard targets.

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Right.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 11	302	600			1			
June 11	303				1			
June 11	305				1			
June 11	307				1			
June 11	309				1			
June 11	311				1			
June 11	313				1			
June 11	315				1			
June 11	317				1			
June 11	319				1			
June 11	321				1			
June 11	304				1			
June 11	306				1			
June 11	308				1			
June 11	310				1			
June 11	312				1			
June 11	314				1			
June 11	316				1			
June 11	318				1			
June 11	320				1			
June 11	322				1			

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

80 feet apart, alternating on the two targets.]

Wind right and rear, 60°, 14 miles an hour; barometer, 30.23; thermometer, 84°; humidity, 59.

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.

Sighting shot, struck the target 3 feet 11 inches below and 3 inches right of center.

TARGET No. 1.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	1.5	0.5	.....	.....	1.7	.....	1.075
.....	1.25	2	.....	.....	1.45	0.425	.....
.....	1	2.5	.....	.....	1.2	0.925	.....
0	.....	1	.....	.....	0.2	.....	0.575
.....	0.25	2.25	.....	.....	0.45	0.675	.....
.....	0.25	3	.....	.....	0.45	1.425	.....
0.5	.....	0.5	.....	0.3	.....	.....	1.075
1.5	.....	1.5	.....	1.3	.....	.....	0.075
1.75	.....	1.5	.....	1.55	.....	.....	0.075
2.5	.....	1	.....	2.3	.....	.....	0.575

Sight had to be adjusted after each shot.
Aimed at bull's-eye.
Round 316, lanyard broke; a new one attached.

Center of impact—	Feet.
Above	0.2
Right	1.575
Mean vertical deviation from center of impact	1.09
Mean horizontal deviation from center of impact	0.69
Mean deviation from center of impact	1.251

TARGET No. 2.

.....	1.25	3.25	.....	.....	1.95	1.792	.....
.....	0.25	2	.....	.....	0.95	0.542	.....
0	.....	1.08	.....	.....	0.7	.....	0.378
0.5	.....	1	.....	.....	0.2	.....	0.458
0.75	.....	1.5	.....	0.05	.....	0.042	.....
0.75	.....	2.25	.....	0.05	.....	0.792	.....
1	.....	0.75	.....	0.3	.....	.....	0.708
1.25	.....	1.5	.....	0.55	.....	0.042	.....
2	.....	1.5	.....	1.3	.....	0.042	.....
2.25	.....	.....	0.25	1.55	.....	.....	1.708

Center of impact—	Feet.
Above	0.7
Right	1.458
Mean vertical deviation from center of impact	0.76
Mean horizontal deviation from center of impact	0.6504
Mean deviation from center of impact	1

Time of firing the 20 rounds, 5 minutes 17½ seconds.

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[Blowback

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 12	323							
June 12	324							
June 12	325							
June 12	328							

[For rapidity with

					Right.			
June 14	327				0			
June 14	328				4			
June 14	329							
June 14	330							
June 14	331							
June 14	332							
June 14	333							
June 14	334							
June 14	335							
June 14	336							
June 14	337							
June 14	338							

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Blowback.	
.....	Blowback. Four attempts failed to explode the primer, due to the firing pin being fouled by residue from previous round. The cartridge was removed and the firing pin was tapped gently with a wooden mallet. Replacing the cartridge it was fired successfully at the next attempt.	
.....	Blowback. One attempt failed to explode primer; the cartridge was removed and the firing pin tapped as in round 324; this failed to show the point of the pin, and snapping, also failed. The block was then dismounted and the firing pin was found broken in three pieces; the point remained in the face of the block, being held by the residue, and was removed with some difficulty. The residue was removed sufficiently to permit the insertion of a new firing pin. The crank shaft was removed and the residue wiped from it. The mechanism was replaced and the third blowback fired at the first attempt.	The blowbacks were secured by unloading the requisite number of rounds, decapping the shells, and thinning the metal of the primers; the shells were recapped and the charges replaced.
.....	Service cartridge. Two attempts failed to explode primer. Firing pin tapped with mallet to force it through surrounding residue. Mechanism cocked again and cartridge fired at first attempt. Total time of firing 3 blowbacks and 1 service round, 26 minutes and 14 seconds.	

accuracy at 1,000 yards.]

Wind from front, 9 miles an hour; barometer, 30.34; thermometer, 70°; humidity, 52.

Elevation by sight, 900 yards. Struck target 25 feet 6 inches left and 1 foot 7 inches below center.

Elevation by sight, 900 yards. Struck target 4 feet 3 inches below, 7 feet left of center.

Aimed at the upper right corner.

Time to fire 10 rounds, 2 minutes and 12¼ seconds.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	4	.....	11	.....	5.854	.....	3.47925
.....	2.75	.....	7.417	.....	4.604	0.10375	.....
.....	1	.....	7.833	.....	2.854	.....	0.31225
.....	1.25	.....	9	.....	3.104	.....	1.47925
3.833	.....	.....	3.833	1.979	.....	3.68775	.....
6.333	.....	.....	8.333	4.479	.....	.....	0.81225
7	.....	.....	5.75	5.146	.....	1.77075	.....
6.67	.....	.....	7	4.812	.....	0.52075	.....

Miss .....

Miss .....

Center of impact—	Feet.
Above	1.854
Left	7.52075
Mean vertical deviation from center of impact	4.104
Mean horizontal deviation from center of impact	1.52075
Mean deviation from center of impact	4.3767

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight

[For rapidity with accuracy at 500 and 1,000 yard targets

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity. 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet*		*Pounds.*	*Inches.*	*Inches.*
June 14	339							
June 14	340							
June 14	341	900						
June 14	342	600						
June 14	344							
June 14	346							
June 14	348							
June 14	350							
June 14	352							
June 14	354							
June 14	356							
June 14	358							
June 14	360							
June 14	362							
June 14	343							
June 14	345							
June 14	347							
June 14	349							
June 14	351							
June 14	353							
June 14	355							
June 14	357							
June 14	359							
June 14	361							

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

on same line, alternating shot by shot on targets.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind from front, 12 miles an hour; barometer, 30.34; thermometer, 70°; humidity, 52.	Sighting shot at 1,000 yards. Miss, high and to the left.	At 1,000 yards. Aimed at the upper left corner.
	Sighting shot at 500 yards. Miss, high and to the left.	At 500 yards. Aimed at bull's-eye.
	Sighting shot at 1,000 yards. Struck target 3½ feet below and 1 foot 10 inches left of center.	Sight adjusted for each shot at each target.
	Sighting shot at 500 yards. Struck target 2 inches above and 8 inches right of center.	

TARGET, 1,000 YARDS.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
	3.5	3.25			2.833	3.55	
	3.833	1			3.167	1.3	
	2.5	0.75			1.833	1.05	
	0.5	0		0.167		0.3	
	3		1		2.333		0.7
	0.75		1		0.083		0.7
	1.833		4.5		1.167		4.2
2		2.25		2.667		2.55	
5.25			3	5.917			2.7
2			0.75	2.667			0.45

Center of impact—	Feet.
Below	0.667
Left	0.3
Mean vertical deviation from center of impact	2.283
Mean horizontal deviation from center of impact	1.75
Mean deviation from center of impact	2.877

TARGET, 500 YARDS.

	1.167		0.917		2.559		0.729
	0.375		0.583		1.767		0.395
0.083			1.75		1.309		1.562
0.583			1.5		0.809		1.312
1.417		0.083		0.025		0.271	
1.667		1.25		0.275		1.438	
2.167		0.208		0.775		0.396	
2.375			0.25	0.983			0.062
3		2		1.608		2.188	
4.167			0.417	2.775			0.229

Center of impact—	Feet.
Above	1.392
Left	0.188
Mean vertical deviation from center of impact	1.289
Mean horizontal deviation from center of impact	0.858
Mean deviation from center of impact	1.548

Time to fire the 20 rounds, 5 minutes and 24½ seconds.

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[To determine time required to fire 1 round, change mainspring.

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 15	363							
June 15	364							

[Dust

June 26	365 to 369							

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

sear spring, firing pin, and extractors, and fire another round.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Done in 1 minute 12⅗ seconds, by Lieut. Harmon.	
.....		

test.]

.....	Breechblock opened without difficulty after being shaken a few times, and the 5 rounds were fired with very little trouble. Some waste was pushed through the bore just once to remove dust from bore. No oil or water was used. Time to open block and fire 5 rounds, 2 minutes 5½ seconds. After firing, the breech mechanism was dismantled and thoroughly cleaned by washing in hot water and soap preparatory to rusting.	Owing to the lack of uniformity in the conditions of the different breech mechanisms when subjected to the first dust test it was considered advisable to repeat this test. In the second dust test all the parts of the different mechanisms were thoroughly washed with hot water and soap; they were then carefully dried and lightly oiled. When subjected to the blast of dust the gun was not cocked. The arrangement for dusting and the material used were the same as in the first dust test. The gun was subjected to a blast of dust for 8 minutes (and 5 seconds accidental).

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Record of firing with Sponsel 6-pounder rapid-fire gun (caliber, 2.244 inches; weight,

[Rust test, gun

Date.	No. of fire.	Sight set at yards.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points. *Left.*	Pressure per square inch of bore.	Recoil.	Counter recoil.
			° ′	*Feet.*		*Pounds.*	*Inches.*	*Inches.*
June 26								
June 28								
June 29								

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752 pounds) at Sandy Hook Proving Ground May 2 to June 29, 1894—Continued.

not cocked.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical and was lowered into the solution just enough to cover the breech mechanism. Before immersing, a soft wood plug wrapped with a piece of cartridge bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber. Sight seat and hole for spring locking pin filled with waste and putty. The depressions at the outer ends of the pins on the extractor cams were also filled with putty. Gun immersed at 3:11 o'clock; gun taken out at 3:36 o'clock; gun in solution 25 minutes.	
.....	Started to open block at 3:48 o'clock. The block could not be moved by hand nor by using a mallet on the handle. Oil was then poured over the block from an oil can, at the same time using mallet on handle and sledge and copper drift on block to drive it down. This operation opened block about half way. The effort to open the block was continued until 5 p. m., but no further progress was made. The block was then closed in the same manner, well oiled, and left overnight. Time, 1 hour 40 minutes 7 seconds.	
.....	Resumed the attempt to open the block at 9:22 o'clock, using oil, sledge, and copper drift. Gun dismounted at 10:16 o'clock after sledging on top of block and failing to move it. The gun was turned upside down and the sledging continued on bottom and top of block alternately, the gun being rolled over to correspond. In this manner the block was finally removed at 1:07 p. m. The crank arm was found broken between the crank and the stud. The mechanism was dismantled and cleaned and burrs dressed down by a machinist. The burrs were in the bearing of the crank shaft and were caused principally by spawls from the cocking lever. The mechanism after being thoroughly cleaned and oiled was assembled and replaced in the gun. The cocking lever was so badly injured that the mechanism could not be operated, and the effort to fire the 5 rounds had to be abandoned. Total time, between 7 and 8 hours.	Firing conducted in the presence of the Ordnance Board. Present: Maj. Frank H. Phipps, Ordnance Department; Capt. Frank Heath, Ordnance Department; Capt. Wm. Crozier, Ordnance Department.

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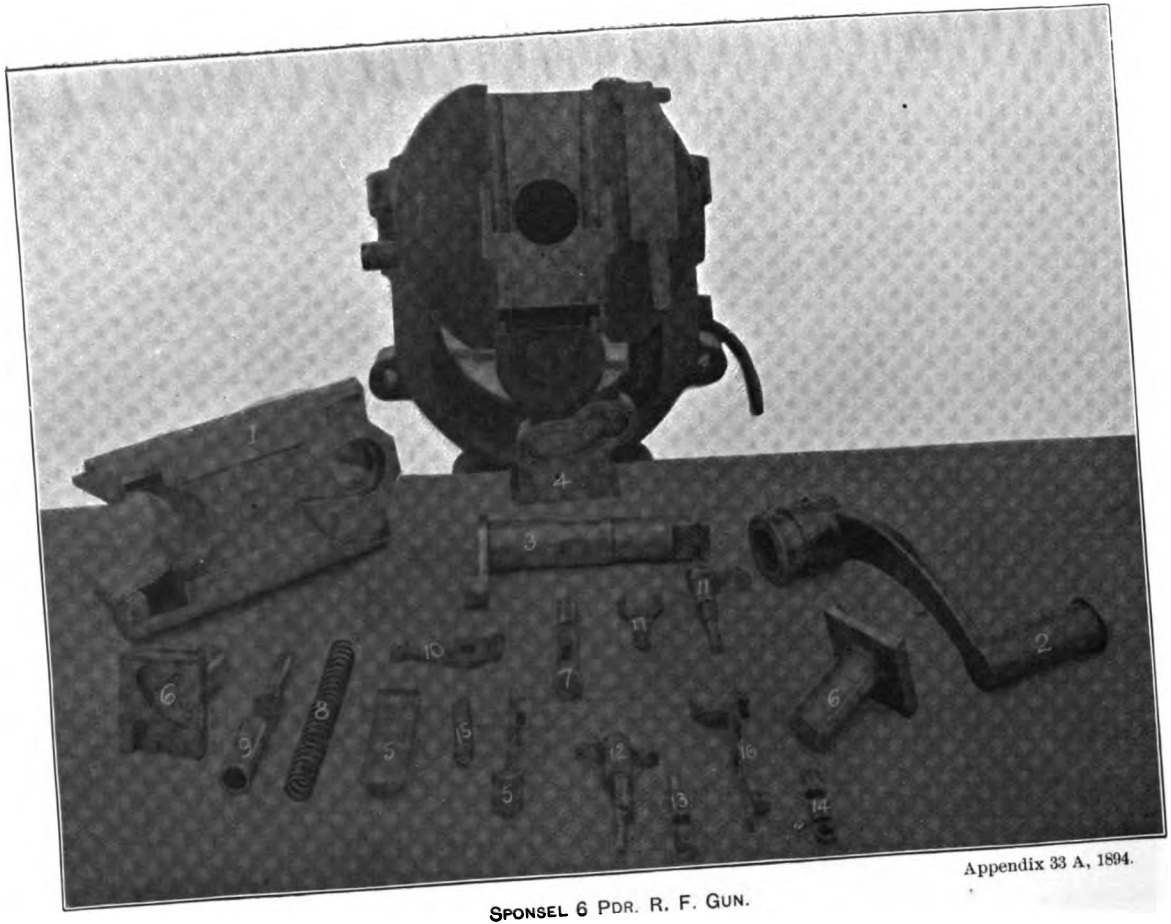

SPONSEL 6 PDR. R. F. GUN.

Appendix 33 A, 1894.

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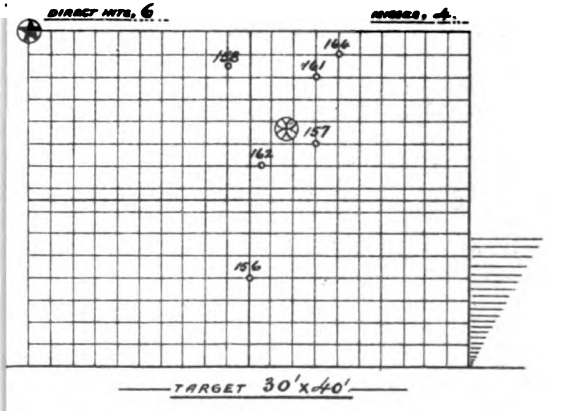
TARGET 3000 YARDS FROM GUN. May 11th 1894.

DIRECT HITS, 6 ... RICOCHETS, 4 ...



ROUNDS.	MILES PER HOUR.	DIRECTION.
156	10	Left of front 85°
157	"	" " "
158	"	" " "
159	"	" " "
160	"	" " "
161	"	" " "
162	"	" " "
163	"	" " "
164	"	" " "
165	"	" " "

5'.83

3'.50

6'.80

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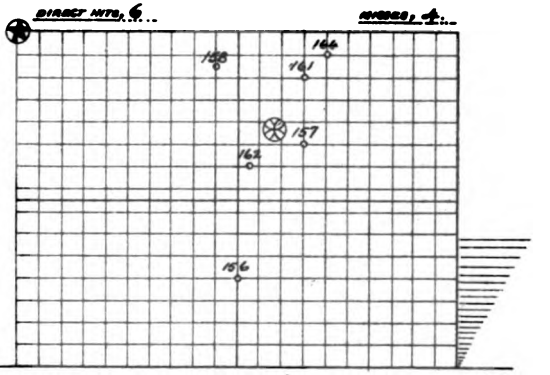
TARGET 3000 YARDS FROM GUN. Nov. 11th 1894.

DIRECT HITS, 6. MISSES, 4.



TARGET 30'x40'

ROUNDS	MILES PER HOUR.	DIRECTION.
156	10	Left 4 from 55°
157	"	" " "
158	"	" " "
159	"	" " "
160	"	" " "
161	"	" " "
162	"	" " "
163	"	" " "
164	"	" " "
165	"	" " "

5'.83

3'.50

6'.80

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APPENDIX 33 B.

TEST OF 6-POUNDER HOTCHKISS RAPID-FIRE GUN.

(8 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL, GOVERNORS ISLAND,
NEW YORK HARBOR,
New York City, October 9, 1894.

SIR: The following report of the test of a Hotchkiss 6-pounder rapid-fire gun is respectfully submitted:

DESCRIPTION OF THE GUN, ETC.

THE GUN.

Nomenclature (Plate I).

1. Tube.
2. Jacket.
3. Locking ring.
4. Breech housing.
5. Recoil thread.
6. Key slot.
7. Extractor slot.
8. Guide ribs.
9. Sight bar slot.
10. Front sight mass.
11. Rifled bore.
12. Shell chamber.
13. Powder chamber.
14. Stop bolt hole.

DESCRIPTION.

The gun designated as the Hotchkiss 6-pounder rapid-fire gun of 45 calibers length is a built-up gun, and consists of three parts—tube, jacket, and locking ring, of tough, open-hearth steel, oil-tempered.

The tube extends the whole length of the bore. About 30 inches from its breech is a cylindrical fillet, which serves as a holding place for the locking ring and jacket to resist longitudinal strain. From this point to the rear the tube is cylindrical. Forward of the fillet the tube is tapered to within about 13 inches of the muzzle, from which point to the muzzle it is cylindrical.

The jacket, which is shrunk on over the tube, carries the breechblock and mechanism, and takes the direct recoil communicated from the cartridge and breechblock.

The jacket is bored transversely on the right side for the crank shaft; on the left for the stop bolt (14); and in the rear, vertically, for the rear sight bar (9).

The locking ring is a collar screwed on over the lip of the jacket and the shoulder of the cylindrical fillet on the tube.

The locking ring carries the front sight mass (10), which is keyed on to permit removal when screwing the gun in the mount.

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The diameters of the tube and jacket, and the amount of shrinkage are so proportioned that when the powder pressure is exerted the transverse and longitudinal strains are distributed between the tube and jacket, and the locking ring acts as a safeguard to prevent displacement.

To preserve the life of the gun, service pressures should not, as a rule, exceed 16 tons per square inch, although the gun is constructed to stand much greater pressures.

The bore is rifled, with a uniform right-hand twist of one turn in 25 calibers. The lands are very narrow in proportion to the grooves and are 24 in number.

The gun is trunnionless, being designed to screw into the mount, the cradle of which is fitted with trunnions.

THE MECHANISM.

Nomenclature (Plates II and III).

1. Breechblock.
1A. Crank slot.
1B. Extractor slot. Not shown in photo.
2. Recoil plate.
3. Crank handle.
3A. Crank handle catch.
3B. Crank handle toe.
4. Crank.
5. Rock shaft.
5A. Rock shaft toe.
6. Hammer.
7. Firing pin.
8. Mainspring.
9. Mainspring sleeve.
10. Mainspring lock.
11. Sear.
12. Sear spring.
13. Extractor.
13A. Extractor cam.
14. Stop bolt.
15. Two screws for 2.
16. Locking spring for 3.
17. Screw for 16.
18. Locking spring for 5.
19. Support for 5 (unscrews from breechblock).

DESCRIPTION.

The system is that of the sliding-wedge breechblock, the block being a rectangular wedge with the front face vertical and the rear face inclined upward and to the front.

The block is hollowed out to receive the firing mechanism, and its sides has slots for the stop bolt head, extractor cam, and crank head. It is also cut away as much as possible to lighten it.

The upper face of the block is hollowed out to form a loading trough, and the front upper edge is beveled to assist in thrusting the cartridge into the chamber.

The block has a movement downward and to the rear in opening the breech, and upward and to the front in closing it, thus giving great power in the first part of the extraction and the last part of loading.

By the movement of the block the breech is opened and closed, the cartridge case is extracted, and the firing mechanism cocked.

The block is guided in its mortise by the guide ribs, Plate I, which are also inclined, but the recoil is all taken on the rear face.

In the front face of the block is dovetailed a hardened plate, designated as the recoil plate; it is held in place by two screws, and takes the direct recoil of the cartridge; through it the firing pin projects striking the primer.

The crank, actuated by the crank handle (3), and with its head in the crank slot (1A) in the block, acts directly in moving the block and retaining it in place. It is journaled in the right side of the breech of the gun, and on its outer end is fitted with a feather, by which it is keyed to the handle. The head is flat to prevent wear, and when the breech is closed rests in an indentation in the crank slot and firmly locks the block.

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The crank handle is fitted with a catch (3A) to hold it on the crank shaft, and with a toe (3B) which acts on the toe of the rock shaft to cock the firing mechanism.

The hammer is mounted on, and actuated by, the rock shaft (5), which passes through and is journaled in the breechblock. It has a detachable firing pin, and is fitted with a toe, through which pressure is exerted by the mainspring. It swings perfectly free in the cavity of the block, and sluggishness due to fouling from blowbacks is impossible. It is also fitted with a notch which acts as a hold for the sear.

The firing pin is a conical point with a split shank fitted with ears, by which it is mounted and held in place in the hammer. A clearance is cut in the block, as shown in figs. 1 and 2, Plate II, for the head of the firing pin when the hammer is blown back by a defective primer.

The mainspring is helical, and is mounted in a sleeve (9) fitted with a toe by which its action is communicated to the hammer. It is held in place in the block by the mainspring lock (10), as shown in figs. 2 and 3, Plate II.

The rock shaft is hexagonal where it passes through the hammer, by which it actuates the latter. Its end passes through the block and is fitted with a catch by which it is held in place.

The hammer is held in the cocked position by the sear, actuated by a sear spring (12) in the block. The sear is pivoted in the side of the block and its notch engages the cock notch on the shaft of the hammer.

The sear also acts as a trigger, the lanyard being hooked directly to it.

The extractor moves directly in a line with the axis of the gun in a T-shaped slot in the gun. It is fitted with a cam (13A) which moves in the extractor cam slot (1B, fig. 2), and which, by the movement of the block, vibrates the extractor back and forth. The front end of the extractor is fitted with a claw to extract the cartridge case. The claw is made separate from the body of the extractor and is designed to withstand heavy shocks, incident to the extraction of a stuck case, without breaking.

The stop bolt is seated in the stop bolt hole in the left side of the breech, and its inner end moves vertically in a slot in the block, and when home serves to prevent the latter from dropping out of the gun when the breech is opened. It is fitted with a spring catch which acts in annular grooves in the stop bolt hole, the outer one being so located that it retains the bolt in place, just clear of the block, when the latter is being dismounted.

All parts of the mechanism, where bearing surfaces occur, are hardened to prevent wear and friction, and the firing point and extractor claw are spring tempered. All component parts of the mechanism, except recoil plates, are interchangeable between guns of this model.

THE SIGHTS.

Nomenclature (Pl. IV).

1. Sight-bar.
2. Sight-bar clamp.
3. Sliding leaf (with peep sight).
4. Sight-bar detent.
4A. Detent slot.
5. Front sight.
6. Front-sight mass.

DESCRIPTION.

Two kinds of rear sights are furnished with this gun—the plain V notch or the closed peep, both either fixed or sliding. The front sight is either a cone, a rifle sight, or a combination of either with a globe

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sight. The rear peep sight is shown in fig. 1; the rear V-notch sight is shown in fig. 4; the combination globe front sight is shown in fig. 2.

The closed peep rear sight consists of a cylinder which is coned from both ends to the center and has its axis in the line of sight. In the cylinder, in the transverse plane passing through the junction of the cones, are two disks which slide past one another and on their edges have V notches which form a square opening. The disks are operated by a pin with a left and right hand screw fitted with a milled head at the end of the barrel, and by means of this screw the square opening, which forms the peep proper, can be enlarged or decreased in size to suit either the eye or the light available.

The combination globe front sight is designed to be used with the peep rear sight.

The cone, or the rifle front sight, is designed to be used with the V-notch rear sight.

The sight bar slides in a slot in the gun and is set at a permanent angle of 2° to the left to compensate for drift. It is unclamped by a small fraction of a turn of the clamp screw to the left, and can be quickly raised or lowered, set at any desired elevation, and again clamped, with one hand. It is fitted with a detent (4), a pivoted projection on the bottom, which slides in a slot (4A) and prevents the bar from being pulled out of the gun. It is fitted with a spring which forms a cushion when the bar is suddenly raised to its limit. It is graduated, in intervals of 100 yards, for ranges from 200 to 4,800 yards.

The slot is open to the rear and permits the movement of the clamp which is attached to and moves with the sight bar, and the graduations are visible at all times above and below the origin.

The sliding leaf consists of a cylindrical barrel carrying either the notch or peep rear sight, and fitted on its under side with teeth, forming a rack by which it is actuated by a pinion in the head of the bar. Its barrel is graduated, in intervals of 5 minutes of arc, from each side of the origin, to 30 minutes.

THE ACCESSORIES.

Nomenclature (Pl. V).

1. Screw-driver.	6. Wiping rod.
2. Lanyard hook.	7. Monkey wrench.
3. Hand extractor.	8. Oil can.
4. Dismounting tool.	9. Sponge and rod.
5. Cleaning brush.	10. Dismounting pin.

Fig. 1 is a top and end view of the accessory chest.

Fig. 2 shows the diaphragm in the box and the arrangement for stowage of accessories and spare parts.

In addition to the accessories above enumerated, stowage room is found in the box for the following spare parts, which are supplied with each gun:

One extractor, 1 mainspring, 1 sear spring, 1 firing pin.

A place is also fitted in the box for stowing the complete sight when it is removed from the gun.

One chest accompanies each gun and contains all the necessary spare parts and accessories for both gun and mount.

It will rarely be found necessary to use the hand extractor, the present model of extractor being specially strong.

The wiping rod is intended to be used to clean the mainspring cavity in the block with waste or rag.

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The monkey wrench is for use with the mount.

The bristle sponge is made removable from the sponge rod, and should be dried after use and kept in the chest.

The dismounting pin is for use with the cap-square screws on the mount, and can also be used on the stop bolt to start the latter if it should have become rusted.

The dismounting tool is T-shaped, two ends being screw-driver form for use on the recoil-plate screws. The third end is used for removing and replacing the firing pin and the mainspring lock.

The chest is fitted with handles and hasp, and the hinges are so arranged that the lid may be quickly removed and replaced.

ACTION OF THE MECHANISM.

The gun having been fired, the action of the mechanism in reloading is as follows:

The breech is opened by pulling the crank handle to the rear. As the crank handle commences to move the crank stud is carried backward in the part of its groove which is concentric with the axis of the crank, therefore the breechblock does not move; during this time the cocking cam acts on the cocking toe and cocks the hammer. The crank stud passing on into the inclined part of its groove causes the breechblock to commence to descend. The extractor, actuated by the movement of the block, commences to move very slowly back with a powerful leverage, due to the inclination of the guide ribs, which starts the cartridge case from its seat. When the breechblock has descended so far as to unmask the bore the change in direction of the extractor stud groove causes the extractor to take a quick violent motion to the rear which throws the cartridge case entirely out of the gun. The breechblock at this point is stopped in its descent by the stop bolt.

The gun is then ready for loading.

The new charge, having been entered in the chamber, is pushed home by hand until the head of the case takes against the hook of the extractor; the breechblock is closed by a reverse movement of the crank handle. As the block rises its inclined upper corner pushes the cartridge and extractor close home. When the block is entirely up its face bears tightly against the head of the cartridge and the crank having passed the vertical position, rests against the body of the gun, so that the block is held secure in four ways: by its own weight pressing on the crank past the center; by the reaction of the crank and handles in firing; by the small spring catch on the crank-handle toe, and by the indentation in the end of the crank head slot.

When the breech is closed the cocking cam is in position to allow the cocking toe, and with it the hammer, to act in firing. The cock notch of the sear is also engaged in that of the hammer, and by pulling the lanyard the latter is released and flies forward, striking the primer of the cartridge.

It is impossible to fire the gun before the breech is entirely closed, for two reasons, viz: The firing pin is not in line with the primer; the cocking toe will catch on the cocking cam before the firing pin can touch the primer.

It is impossible for the breach to fly open, for the four reasons above cited. (*See* Closed.)

It is impossible to bring a shock on the cartridge primer in closing the breech, as the face of the breechblock slides along the head of the cartridge, thus giving perfect security in loading and unloading.

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DIRECTIONS FOR DISMOUNTING AND ASSEMBLING THE MECHANISM.

NOTE.—For greater convenience in dismounting and assembling the shoulder bar should be removed, although this is not necessary.

TO REMOVE THE BREECHBLOCK FROM THE GUN.

The breech being closed, unhook the lanyard, grasp the stop bolt with the left hand, and, pressing down the catch spring, with the thumb pull the stop bolt out from the gun till the catch snaps into the outer annular groove in the stop bolt hole. In this position the bolt is held with its end clear of the block.

Remove the block by turning the crank handle as in opening the breech, but continuing the motion till the crank head is clear of the slot. The left hand should support the block in its descent, and the right hand used to assist as soon as the crank is clear.

TO DISMOUNT THE MECHANISM.

NOTE.—This can be done without removing the block from the gun if necessary.

Stand the block on its upper end, recoil plate toward the operator, uncock the mechanism by tripping the sear, and easing down the hammer by holding the rock shaft toe.

Insert the large nipple end of the dismounting tool (4, Pl. V) in the slot in the head of the mainspring lock, press down the lock until the head is released from the block, and turn, in either direction, one-quarter of a turn. The mainspring will, in this position, force out the lock, and the lock, sleeve, and spring may then be lifted out together.

With the thumb of the left hand press in the catch of the rock shaft, and with the right hand pull out the latter.

Lift out the hammer, slide out the sear, and remove the sear spring.

TO ASSEMBLE THE MECHANISM.

Proceed in the reverse order.

In assembling it will be noticed that if the sear be held back slightly against its spring the shaft of the hammer centers itself for entering the rock shaft by resting on a shoulder cut for that purpose in the side of the block.

TO REPLACE THE BREECHBLOCK.

Cock the hammer, see that the stop bolt is clear and the crank turned down.

Enter the block, and when the crank head has entered the slot turn the crank handle as in closing the breech. Return the stop bolt by a smart tap on the head.

TO REMOVE THE FIRING PIN.

The hammer being out of the block, grasp it with the left hand and with the right hand insert the cupped end of the dismounting tool in the rear side of the head of the hammer and over the end of the firing pin; with the tool turn the pin one-quarter turn, in either direction, until the ears on the firing pin fall into the slot in the hammer, and by a slight pressure on the tool the pin can be forced out a short distance and then wholly withdrawn by the left hand.

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TO REPLACE THE FIRING PIN.

Insert the pin in the hammer up to the shoulder and hold it in this position by pressing the point with the forefinger. With the dismounting tool turn the pin one-quarter turn until the ears on the shank fall into their locking recesses in the head of the hammer.

TO REMOVE THE SIGHT BAR.

Turn the detent, shown in (4) fig. 3, Pl. IV, until it is in coincidence with the open slot in the gun; unclamp the bar and lift it out.

AMMUNITION.

Nomenclature (Pl. VI).

(Figs. 1 and 2, shell.)

1. Point.
2. Swell.
3. Body.
4. Base.
5. Rotating band.
6. Chamber.
7. Gas check.

(Fig. 3, case shot.)

8. Head.
9. Body.
10. Base.
11. Bullets.
12. Packing.

(Figs. 4 and 5, fuse.)

13. Body.
14. Plunger.
15. Striker.
16. Detonator.
17. Detonator cup.
18. Screw cap.

(Fig. 6, primer.)

19. Cup.
20. Cap.
21. Anvil.
22. Flash holes.

(Fig. 8, cartridge case.)

23. Neck.
24. Body.
25. Head.

DESCRIPTION.

The ammunition is put together in a manner similar to that for breech-loading small arms. It consists of a cartridge case, in the base of which is a percussion primer for center fire, and the projectile.

The drawn metal cartridge case is of brass, and, as its name implies, is drawn from the solid metal to shape.

The primer consists of a small brass case shaped at the top to form an anvil; the bottom is closed by a cap containing the fulminate.

The projectiles are of three kinds—common shell, steel shell, and case shot. The two kinds of shell are similar in construction, except that the base of the steel shell is an independent piece, whilst that of the common shell is a part of the casting, and the point of the steel shell is sharp, whilst that of the common one is cut off. The two may always be recognized by the difference in point. The shoulder of the shell is very slightly enlarged in diameter to prevent it from wabbling in the bore. Rotation is given to it by means of a brass rotating band (5), which is fitted over a series of small grooves cut around the wall of

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the shell. The squeeze caused by forcing the shell through the bore molds the band into the grooves, thus leaving shearing surface enough to insure perfect rotation from the lands cutting into the soft metal, whilst the creases caused by the molding give space for an easy flow of the sheared metal. The shells are turned smooth all over and are finished with great care, the steel ones being specially tempered to give penetrating power.

In order to have great penetrating power the point of the shell must be solid, which necessitates the use of a base fuse; the wall of the shell must also be quite thick to resist the shock of impact; the base therefore becomes the weakest point of the shell, and on explosion it would be blown out without the walls of the shell being fractured, if some means were not employed to counteract this tendency. With this in view, the base (4) of the steel shell is made of a separate piece of metal secured in the bottom of the shell and so shaped on the inside that when the explosion takes place it is pinched both against the wall and the fuse, thus holding all fast until the shell breaks all over. To further insure perfect sealing of the base the fuse is put entirely on the inside of the steel shell, as shown in fig. 2.

Ammunition.

Steel shell:		
Loaded weight	pounds	6
Weight of bursting charge	grains	1,750
Common shell:		
Loaded weight	pounds	6
Weight of bursting charge	grains	1,320
Case shot:		
Total weight	pounds	6.5
Number of balls		40
Weight of empty cartridge case	pounds	2
Weight of charge, black powder (about)	do	2
Weight of complete cartridge	do	10
Length of complete cartridge	inches	19
Weight of ammunition chest, empty	pounds	25
Weight of ammunition chest, filled	do	135
Number of rounds		11

Range table. 6-pounder Hotchkiss rapid-fire gun, L/45.

[Charge, about 2 pounds black cubical powder; projectile, 6 pounds; initial velocity, 1,870 foot-seconds; length of line of sight, 37.18 inches; angle of jump, 0°; permanent angle, 2°. The sight is inclined 2° to the left and compensates for drift. The penetration in wrought iron at 100 yards is about 4 inches; in steel, about 3 inches.]

Range.	Angle of elevation.	Angle of fall.	Remaining velocity.	Time of flight.	Range.	Angle of elevation.	Angle of fall.	Remaining velocity.	Time of flight.
Yards.	° ′	° ′	*Ft. secs.*	″	*Yards.*	° ′	° ′	*Ft. secs.*	″
100	0 5	0 5	1,810	0.2	2,100	2 43	4 1	1,039	4.7
200	0 10	0 10	1,754	0.3	2,200	2 54	4 20	1,022	5
300	0 15	0 16	1,699	0.5	2,300	3 6	4 40	1,006	5.3
400	0 21	0 22	1,645	0.7	2,400	3 19	5 2	991	5.6
500	0 26	0 29	1,593	0.9	2,500	3 32	5 24	977	5.9
600	0 32	0 37	1,543	1.1	2,600	3 45	5 46	964	6.2
700	0 39	0 45	1,494	1.3	2,700	3 58	6 9	951	6.6
800	0 45	0 54	1,447	1.5	2,800	4 12	6 33	939	6.9
900	0 52	1 3	1,401	1.7	2,900	4 27	6 57	927	7.2
1,000	0 59	1 13	1,357	1.9	3,000	4 42	7 22	915	7.5
1,100	1 7	1 24	1,315	2.1	3,100	4 57	7 48	903	7.9
1,200	1 15	1 36	1,276	2.3	3,200	5 12	8 14	892	8.2
1,300	1 23	1 49	1,239	2.6	3,300	5 28	8 41	881	8.6
1,400	1 32	2 3	1,205	2.8	3,400	5 44	9 9	871	8.9
1,500	1 41	2 18	1,174	3.1	3,500	6 1	9 38	861	9.3
1,600	1 50	2 33	1,146	3.3	3,600	6 18	10 7	852	9.6
1,700	2 0	2 49	1,120	3.6	3,700	6 35	10 38	842	10
1,800	2 10	3 6	1,097	3.9	3,800	6 53	11 9	833	10.3
1,900	2 20	3 24	1,076	4.2	3,900	7 11	11 41	824	10.7
2,000	2 31	3 42	1,057	4.4	4,000	7 30	12 13	816	11.1

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The following programme was adopted for the test:

The gun to be carefully examined by the board. The number of the parts of the breech mechanism, their strength, simplicity, and certainty of action to be noted; also the ease, safety, and certainty of the breech mechanism as a whole. Note carefully the action of the firing pin and extractor, and the maximum outward position of the cartridge when it can be pushed home by the breechblock. During this examination 50 rounds to be fired at will.

VELOCITY.

Five rounds to be fired for velocity with full charges.

ACCURACY.

Ten rounds to be fired at each range of 1,000 yards, 1 mile, and 3,000 yards, the same conditions of aiming being repeated at each round, and the mean deviations determined.

RAPIDITY.

Determine number of rounds that can be fired in 5 seconds, 3 trials, also number of rounds that can be fired in 1 minute, 3 minutes, and 5 minutes, respectively, and, finally, the time required to fire 100 rounds, noting carefully during the firing, and especially at end of each 25 rounds, the condition of the gun as regards heat and ease and certainty of action. Two detachments of men alternating every 25 or 50 rounds, as may be thought advisable.

RAPIDITY WITH ACCURACY.

Fire 10 aimed shots as rapidly as possible at the 1,000-yard and 1-mile targets. Also 10 aimed shots at targets in same line and ranges of 500 and 1,000 yards alternately; also 10 aimed shots alternately at targets at about 500 yards range, placed about 75 feet apart.

DUST.

The mechanism to be exposed to a blast of fine dust in such manner as to insure its being uniformly and equally covered with the dust, after which 20 rounds to be fired as rapidly as possible.

EXCESSIVE CHARGES.

The gun to be fired with 5 charges, giving gradually increasing pressures up to 45,000 pounds per square inch, if such pressures are attainable.

DEFECTIVE CARTRIDGES.

The gun to be tested with defective cartridges in the same manner as is usual in the trial of small arms.

Any rounds that may remain after the above tests to be expended in such manner as may be deemed best by the board, as a result of the circumstances developed; the last five rounds to be fired after the mechanism of the gun has been rusted in a thorough and uniform manner.

In accordance with the programme the test of the gun was commenced

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on May 25 last. The length of the gun is 45 calibers from the seat of the head of the cartridge case to the muzzle. The action of the mechanism in manipulation and deliberate firing was found to be satisfactory. All the parts of the mechanism are visible and can be removed and exchanged with facility. In case of injury to the extractor it can be replaced without wholly removing the block from the gun, and should it be broken the empty case can be extracted with a hand extractor. The exchange of extractors, however, can not be effected with the block in any normal position. The stop bolt must be disengaged and the block lowered some distance beneath its normal position when open before it clears the extractor and permits the withdrawal of the latter. The block can be removed, leaving the crank, crank handle, and extractor in the gun. The gun can not be fired before the breech is closed, although the sear can be disengaged, and the breech seems to have no tendency to fly open from the shock of discharge.

The cartridge can be pushed home by the breechblock in closing at a distance of 1.5 inches from its seat. Starting with the breech closed, the mechanism was removed and completely dismantled by one man, the representative of the gun, in 56½ seconds, using a screw-driver, drift, and key. The mechanism was assembled, replaced in the gun, and the motion of firing executed all in 1 minute and 46 seconds.

A test was made of the time required to fire 1 shot, remove and replace mainspring, sear spring, firing pin, and extractor, these being the parts most liable to injury during action, and fire a second shot. The time between the 2 shots was 1 minute 37⅘ seconds, two trials being made to get a proper start.

The weight of the breech mechanism complete, including the extractor and handle, is 64¾ pounds, and the number of its parts is 20.

VELOCITY.

The maximum velocity determined in firing 5 rounds was 1,824 foot seconds; the minimum, 1,793 foot seconds, and the mean, 1,812 foot seconds.

ACCURACY.

At 1,000 yards range the mean vertical deviation of 10 shots from the center of impact was 1.34 feet; the mean horizontal deviation, 1.05 feet, and the mean deviation, 1.70 feet. At the first attempt to make a target at the mile range 8 shots were fired, when the attempt was given up on account of the wind, which was blowing from the right and rear at the rate of 30.16 miles per hour. At the second attempt the following results were obtained: Mean vertical deviation from center of impact, 1.9 feet; mean horizontal deviation, 2.25 feet; mean deviation, 2.945 feet. At the first attempt to make the target at 3,000 yards 13 shots were fired, when the attempt was given up because of 2 misses in case of 2 shots, which would have been the eighth and ninth of the target. The last shot to hit struck 16 feet left, and the probabilities are that a sudden change of wind between the gun and the target caused this, and carried the next 2 shots clear off the target. At the second attempt the results were 8 hits, 2 misses; mean vertical deviation from center of impact, 4.8 feet; mean horizontal deviation, 4.66 feet; mean deviation, 6.7 feet. Representations of the targets are inclosed, Pl. VII.

The aim is disturbed by firing both in direction and elevation.

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RAPIDITY.

The number of rounds fired in 5 seconds at the first trial was 2; at the second trial, 1, when the lanyard broke; at the third trial, 3.

The number of rounds fired in 1 minute was 28, and in 3 minutes 83; the number 28 being that fired in the first minute of the 3-minute test; 2 missfires, caused by pulling the lanyard too soon, were counted as rounds fired. In the 3-minute test the officers loading and firing exchanged positions at the end of 1½ minutes.

The time required for firing 100 rounds was 4 minutes 25 seconds, with 2 missfires as above, which were counted. In firing for rapidity the ammunition was placed on a table in rear of the gun and close to it. Four persons at a time, 2 officers and 2 enlisted men, were, at the request of the representative of the company, employed in the service of the piece. Three persons would have sufficed, although the time would probably have been increased in firing 100 rounds and the number of rounds fired in 1 minute and in 3 minutes would have been diminished. The officers loading and firing exchanged positions after each 25 rounds. The man operating the breechblock was relieved at the same intervals by a fresh man. The mechanism worked satisfactorily throughout. After firing 75 rounds soft solder would melt when placed anywhere along the chase, temperature probably about 375° F. After the 100 rounds a thin sheet of lead held against the gun near the muzzle was softened, temperature probably about 600° F. A cartridge was inserted in the chamber immediately after firing the 100 rounds to see whether the heat would be sufficient to explode it; after having remained 4 minutes it was removed.

RAPIDITY WITH ACCURACY.

In firing for rapidity with accuracy at 1,000 yards 4 sighting shots were used, then 10 shots at the target, of which 1 was a miss. Of the remaining 9 the mean vertical deviation from the center of impact was 1.796 feet, the mean horizontal deviation 1.179 feet, and the mean deviation 2.149 feet. The 10 rounds were fired in 2 minutes 36½ seconds.

At 1 mile range 3 sighting shots were used, then 10 at the target, of which 1 was a miss. Of the remaining 9 the deviations were: Mean vertical, 3.12 feet; mean horizontal, 2.082 feet; mean, 3.751 feet. Time for the 10 rounds, 1 minute 33½ seconds.

At 2 targets in the same line, at ranges of 500 and 1,000 yards, 1 sighting shot at each target was followed by 10 shots at each, alternating with every shot. Upon the 500-yard target there was 1 miss. Of the 9 hits the deviations were: Mean vertical, 0.859 feet; mean horizontal, 0.957 feet; mean, 1.286 feet. Upon the 1,000-yard target there were 2 misses, and for the remaining 8 shots the deviations were: Mean vertical, 2.292 feet; mean horizontal, 1.55 feet; mean, 2.766 feet. The 20 shots were fired in 5 minutes 22¾ seconds. The sight was adjusted for each shot at each target.

At 500 yards range 2 targets were placed 80 feet apart and 12 shots fired at one and 8 at the other; this was through inadvertence in not changing after 2 of the shots at Target No. 1 to Target No. 2. Of the 12 shots at Target No. 1, 1 struck an iron telegraph pole and was thrown out. There were 11 hits, of which the deviations were: Mean vertical, 1.62 feet; mean horizontal, 1.243 feet; mean, 2.04 feet. Upon Target No. 2 there were 8 hits, and the deviations were: Mean vertical, 0.544 feet; mean horizontal, 0.755 feet; mean, 0.931 feet. The time to fire

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the 20 rounds was 3 minutes 28⅜ seconds. Representations of the targets are inclosed, Pl. VIII.

DUST.

There were 2 tests made of the effect of dust upon the breech mechanism. At the first test the gun was taken to the blacksmith shop to be dusted without any part being cleaned in any degree. Care was exercised to avoid removing residue from the breech mechanism in handling the gun. The gun was cocked and was submitted to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable. The blue prints attached to the firing records show the method adopted for dusting the mechanism. "A" is a lead pipe leading from the pine box "C" to the hand bellows in the blacksmith shop. One blue print shows the apparatus at work, the other shows it at rest.

The dust used was burnt sand from the proof butts. The passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose.

After being dusted the gun was remounted and the time to open the breechblock and fire the 5 rounds was noted.

The breechblock could not be moved at all by means of the handles. An effort was then made to open it by using a carpenter's mallet on the under side and putting a strain on the handles at the same time. This failed and a sledge hammer was tried in the same manner, using a piece of hard wood on the block. All efforts to move the block more than about one-sixteenth of an inch failed until everything was deluged with oil. After this was done it required from ten to fifteen minutes to open it. The sledge was used as above described, first to start the block and then to close it. Continuing thus, a little was gained each time, oil being used freely. The dust was gradually worked out of the mechanism, dropping on the platform in the form of mud. After getting the block well started it was worked back and forth by hand, still adding oil. In this manner it was finally fully opened.

The bore was then sponged out to remove the one-half pint, more or less, of sand which it contained and 5 rounds were fired. Time to open block and fire the 5 rounds, 38 minutes 39½ seconds.

In a second dust test all the parts of the different mechanisms were thoroughly washed with hot water and soap. They were then carefully dried and lightly oiled.

When subjected to the blast of dust the gun was not cocked.

The arrangement for dusting and the material used were the same as in the first dust test.

The gun was subjected to a blast of dust for 8 minutes, after which the block could not be opened by hand. A mallet was used on the handle and failed. A sledge and block of wood were then used on the block, and in this manner it was opened. It was then opened and closed a number of times by hand with the assistance of a mallet, and the dust worked out of the mechanism in the endeavor to manipulate it by hand alone. The dust was removed from around the extractor. The bore was wiped out with dry waste, and 5 rounds fired.

In each of these 5 rounds the block had to be opened by using a mallet on the handle, and had to be closed by one man working on the handle and another using a mallet on the bottom of the block. No oil or water used.

Time to open block and fire 5 rounds, 22 minutes 47 seconds.

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In sledging the block open one blow of the sledge accidentally missed the wooden drift and struck the rear under edge of the breechblock, slightly burring the metal. Burr removed.

It was decided to fire 5 rounds instead of 20, after dusting, because of scarcity of ammunition.

EXCESSIVE PRESSURES.

At the first test for excessive pressures 1 ounce of rifle powder was added to the charge. The pressure was 34,314 pounds per square inch. As this pressure was near the normal, 4 ounces of rifle powder were, at the next round, added to the charge, with a resulting pressure of 64,600 pounds. The powder gas blew back through the primer. The shell was wedged back tightly against the breechblock, which could not be moved by the handles. It was started by means of a sledge hammer and a copper drift, pressure being maintained on the handles. When opened the mechanism was found to be completely filled with powder residue, but upon being taken apart and cleaned no injury of any character was discovered. Firing for other features of the test was resumed, and the excessive charge test completed at a later period, the 3 remaining charges being 1 ounce of rifle powder added to each, with the resulting pressures 37,218 pounds, 35,431 pounds, and 36,200 pounds, respectively. The cartridge was dished near the choke at each round.

DEFECTIVE AMMUNITION.

Defective cartridges prepared in three ways were fired. In the first case the cartridge case was prepared by filing obliquely through the edge of the rim, so as to just show an opening to the interior at the junction of the wall and head. The slots were at the extremities of two diameters, at right angles with each other. Cartridge placed in gun so that the solid part of the rim came opposite the extractor.

There was quite an escape of gas, as a matter of course, covering nearly all the parts of mechanism with residue.

The breechblock was opened by one man, after several trials. Case extracted easily. Block worked then without much difficulty.

The second cartridge was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other, and each was halfway between the primer and the rim.

Breechblock opened by one man, after several trials, but with considerably more difficulty than previous round.

A service cartridge was then fired. Breechblock worked easily. Time not noted. Three blow backs were secured by unloading the requisite number of rounds, decapping the shells, and thinning the metal of the primers. The shells were then recapped and the charges replaced.

The first and second blow-back cartridges were fired, and the block worked well. In the third blow back the primer exploded, but failed to explode the charge.

A service charge was then fired.

Another blowback was then prepared and fired at first attempt, followed by a service round, both without difficulty.

TIME.

	Min.	Secs.
To fire two blow backs, failure of third, and one service round	1	21¾
To fire one blow back and one service round	0	12
To fire three blow backs and two service rounds	1	33¾

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RUST.

In rusting, the gun was not cocked. The breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap. The gun was immersed in a solution of 15 per cent sal-ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical and was lowered into the solution just enough to cover the breech mechanism.

Before immersing, a soft-wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber.

The main bolt cut in its bearing in opening during the second dust test. The bolt and its bearing were dressed before the gun was immersed.

Gun in solution, 25 minutes.

The breechblock could not be opened by hand, nor by using a mallet on the handle. It was opened by using a sledge and copper drift. A cartridge was inserted, but the mechanism failed to work. It was dismantled, roughly cleaned, replaced and the five rounds fired.

Time to open block and fire 5 rounds, 35 minutes.

After having fired about 300 rounds the detachable point of the firing pin was one morning found to be broken, and although the point was not unserviceable it was replaced by a new one. It is considered probable that this break occurred through the snapping of the lock with the gun unloaded, by parties making unauthorized examination of the gun. In changing the firing-pin point the face plate of the breechblock was found to be upset and slightly cracked around the hole for the firing pin, probably by the excessive pressure of 64,600 pounds, heretofore noted. The plate was dressed a little by a machinist.

With the above-noted exception of the firing-pin point, no change of any of the parts of the mechanism was made during the test.

The firing and loading were done by Lieut. M. F. Harmon, First Artillery, and Lieut. F. P. Peck, Ordnance Department. During most of the critical portions of the test the representative of the gun was present.

The following table shows in summary the general results of the test which was commenced on May 25, and ended on June 28, 1894, 370 rounds being fired:

Weight	pounds	792
Caliber	inches	2.244
Length	calibers	45
Weight of breech mechanism	pounds	64¼
Number parts breech mechanism		20
Time to dismantle breech mechanism	seconds	56¼
Time to assemble breech mechanism		1m 46s
Distance from seat in chamber at which breechblock will force cartridge home	inches	1¼
Time to fire one round, change mainspring, sear spring, firing pin, and extractor, and fire another round		1m 37s
Time to fire 100 rounds		4m 26s
Number of rounds fired in 1 minute		28
Number of rounds fired in 3 minutes		83
Number of rounds fired in 5 seconds, first trial		2
Number of rounds fired in 5 seconds, second trial		1
Number of rounds fired in 5 seconds, third trial		3
Time to fire 2 defective and 1 service cartridge (not noted accurately; did not exceed 15 minutes).		

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Time to fire 5 rounds after dusting, 1st test 38m 39½s
Time to fire 5 rounds after dusting, 2d test 22m 47s
Time required to fire 3 blow backs and 1 service cartridge..... 1m 33½s
Time required to open breechblock and fire 5 rounds after rusting, minutes. 35
Mean velocity.....foot seconds.. 1,812

	Accuracy.			Accuracy with rapidity.		Alternating (two) 500 yards.		Alternating 500 and 1,000 yards.	
	1,000 yards.	1 mile.	3,000 yards.	1,000 yards.	1 mile.	No. 1.	No. 2.	500 yards.	1,000 yards.
Mean vertical deviation....feet..	1.34	1.9	4.81	1.80	3.12	1.62	0.54	0.86	2.29
Mean horizontal deviation..do...	1.05	2.25	4.65	1.18	2.08	1.24	0.76	0.96	1.55
Mean deviation.....do...	1.70	2.95	6.70	2.15	3.75	2.04	0.93	1.29	2.77
Number of hits	10	10	8	9	9	8	11	9	8
Number of misses.....	0	0	2	1	1	0	0	1	2
Time to fire	.....	.....	.....	2m 36½s	1m 33½s	.....	.....	.....	.....
Time to fire both targets.....	.....	.....	.....	.....	.....	3m 23½s		5m 22½s	

Firing record and eight plates are inclosed.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3089)
ORD 94——29

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Record of firing with Hotchkiss 6-pounder rapid-fire gun (caliber 2.244 inch

[Object of firing: test of

Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore
			° ′	*Feet.*		*Pounds*
May 25	1	Lot 560.				
May 25	2					
May 25	3					
May 25	4					
May 25	5					
May 25	6					
May 25	7					
May 25	8					
May 25	9					
May 25	10					
May 25	11					
May 26	12					
May 26	13			1,827 1,820		
May 26	14			1,823 1,824		
May 26	15			1,820 1,808		
May 26	16			1,809 1,798		
May 26	17			1,799 1,787		
				$50+1\frac{1}{2}^{0}$		

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weight 792 pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894.

6-pounder rapid-fire gun.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		This gun is 45 calibers long from seat of head of cartridge case to muzzle.
		Weight of breechblock and breech mechanism complete, including extractor and handle, 64¾ pounds.
	Recoil, 2¼".	
		Starting with the breechblock closed, the breech mechanism was removed and dismantled by 1 man (representing the gun) in 56½ seconds, using screw-driver, drift, and key.
	Cartridge stuck. Found later to have been caused by residue. The same thing occurred later while practicing with another projectile, and the same indication of residue as was found on the first was here also. Cold gun; residue dries and cakes.	
		The mechanism was assembled, replaced in the gun, and the motion of firing executed all in 1 minute 46 seconds.
		The breech mechanism of this gun consists of 20 pieces.
		The time was taken by the proof officer, using a stop watch which reads to one-fifth of a second.
	Warming charge.	Lieuts. Harmon, First Artillery, and Peck, Ordnance Department, did all the loading and firing.
		The gun is fired by means of a lanyard.
		The breechblock will force the cartridge home when it is 1½ inches short of its seat in chamber.
		Cylinder filled with glycerin and water.
		Velocities taken by Lieut. F. P. Peck, Ordnance Department.

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Record of firing with Hotchkiss 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[For rapidity

Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity. 125 feet from muzzle	Deflection points.	Pressure per square inch of bore.
			° ′	*Feet.*		*Pounds*
May 26	18 to 22					
May 26	23 to 122					

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792 pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894—Continued.

100 rounds.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		Rounds 34 and 111 both missed fire.
		Rosin melts after 35 rounds.
		After firing 75 rounds soft solder melts anywhere along chase.
		A thin sheet of lead held on the outside of the gun near the muzzle was softened so as to be pulled apart by hand after firing 100 rounds.
		A cartridge was inserted immediately after firing the 100 rounds; it remained 4 minutes in the chamber, and was then removed.
		In firing for rapidity the ammunition was placed on a table in rear of the gun and as close to it as possible without interfering with the handling of the gun.
.....	Preliminary rounds, 2 degrees elevation	Taking the ammunition from this table 4 men served the gun.
		Four men were employed at the request of the representative of the gun. There is no greater necessity for the employment of 4 men with this gun than with guns of other designs.
		The greater weight of the breech block is quite compensated for by the better location of the handle for closing it.
		Employing only 3 men, however, would undoubtedly have increased the time required to fire 100 rounds.
		Lieuts. Harmon and Peck alternated in loading and firing, changing after each group of 25 rounds.
		The breechblock was closed by 2 enlisted men alternating with each other, the change being made at the end of each group of 25 rounds.
		There was no necessity for using 2 men for this purpose; 1 man could have performed the work involved without difficulty.
		Time to fire 100 rounds and 2 misfires, 4 minutes 26 seconds.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure, per square inch of bore.
			° ′	*Feet.*	*Right.*	*Pounds.*
May 29	123		2 40		0	
May 29	124		2 23		0	
May 29	125		2 5		1	
May 29	126		2 15		1¼	
May 29	127		2 16		1⅛	
May 29	128		2 16		2	
May 29	129		2 16		2	
May 29	130		2 16		2	

[For accuracy

P. M.						
May 31	131		4 20		6	
May 31	132		4 32½		4	
May 31	133		4 45		2	
May 31	134		4 45		1	
May 31	135		4 46		½	
May 31	136		4 46		½	
May 31	137		4 46		½	
May 31	138		4 46		½	
May 31	139		4 46		½	
May 31	140		4 46		½	
May 31	141		4 46		½	
May 31	142		4 46		½	
May 31	143		4 46		½	

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792 pounds), at Sandy Hook Proving Ground, May 25 to June 23, 1894—Continued.

accuracy at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 30°; 16 miles an hour; barometer, 29.99; thermometer, 58°; humidity, 51.	Elevation by sight, 1,600 yards. Struck 160 yards beyond and to the left. Elevation by sight, 1,400 yards. Struck 125 yards beyond, in water. Elevation by sight, 1,200 yards. Struck 51 yards in front, and ricochetted through 10 feet above and 2½ feet left of center. Elevation by sight, 1,300 yards. Struck target 2½ feet below and 11 feet left of center. Elevation by sight, 1,410 yards. Struck 80 yards in rear and 2 feet left of target. Struck target 3½ feet below and 4 feet left of center. Struck 2 feet below and 11 feet left of center. Struck target 6 inches above and 10½ feet left of center.	Aimed at the upper left corner. Firing pin found broken Monday morning, May 28. A new firing pin was put in. Each point on drift scale equals 5 feet of arc. Peepsight used, the open sight having been removed and the peep substituted this morning before the firing began, by the representative of the gun. Firing suspended on account of wind.

at 3,000 yards.]

Wind from left and rear, 85°, 9 miles an hour; barometer, 29.81; thermometer, 56°; humidity, 88.	Elevation by sight, 2,750 yards. Struck 95 yards in front and 30 yards right of target. Elevation by sight, 2,850 yards. Struck 40 yards in front and 5 yards right of target. Struck 60 yards in rear and 3 yards right of target. Struck target 5 feet below and 4 feet right of center. Struck target 3 feet above and 4½ feet left of center. Struck target 4 feet above and 8 feet left of center. Struck target 15 feet above and one-half foot left of center. Struck target 1 foot above and 9 feet left of center. Struck target 2 feet above and 10 feet left of center. Struck target 1½ feet below and 3 feet left of center. Struck target 5 feet above and 16 feet left of center. Struck 110 yards beyond and on line. Miss, could not be located.	Aimed at a board nailed to the upper left corner of target. Target not platted. This range for this gun, sight only used for direction. Target could not be seen, owing to intervening shrubbery.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure, per square inch of bore.
			° ′	*Feet.*		*Pounds.*
May 31	144					
May 31	145					
May 31	146					
May 31	147					
May 31	148					
May 31	149					
May 31	150					
May 31	151					
May 31	152					
May 31	153					
May 31	154					

[For

June 1	155					
June 1	156 to 236					
June 1	237 to 242					
June 1	243 to 245					

Digitized by Google

792 pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894—

accuracy at 1,000 yards.]

Wind, strength and direction.		Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.								General
Wind from left and rear 45°; barometer, 29.81; thermometer, 56°; humidity, 88.	Miles per hour.	Elevation by sight, 990 yards. Struck target 4½ feet above and 4½ feet left of center. TARGET.								Aimed at the u Firing conduct Peck, Ordnan
		From center of target.				From center of impact.				
		Vertical.		Horizontal.		Vertical.		Horizontal.		
		Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	Center of impac Above ..... Left ..... Mean vertical d center of imp Mean horizont from center o Mean deviation of impact ....
	6	4.5	.....	.....	3	1.45	.....	1.25	.....	
	6	3.5	.....	.....	5	0.45	.....	.....	0.75	
	5	3.5	.....	.....	3	0.45	.....	1.25	.....	
	5	1.5	.....	.....	3	.....	1.55	1.25	.....	
	4	1	.....	.....	4	.....	2.05	0.25	.....	
	4	2.5	.....	.....	5	.....	0.55	.....	0.75	
	4	5.5	.....	.....	5	2.45	.....	.....	0.75	
	4	4.5	.....	.....	5	1.45	.....	.....	0.75	
	3	3.5	.....	.....	6.5	0.45	.....	.....	2.25	
	3	0.5	.....	.....	3	.....	2.55	1.25	.....	

rapidity.]

.....	Fired to sea to note the place of striking.
.....	Rounds fired in 1 minute, 28; rounds fired in 3 minutes, 83. The number of rounds fired in 1 minute was determined by noting the number fired in the first minute of the 3-minute test. Two missfires counted as rounds fired.
.....	Rounds fired in 5 seconds, first trial, 2; rounds fired in 5 seconds, second trial, 1; lanyard broke; rounds fired in 5 seconds, third trial, 3. In these firings the arrangement of the ammunition and the number of men serving the gun were the same as in the 100-round test for rapidity. In the 3-minute test Lieuts. Harmon and Peck alternated in loading and firing, changing at the end of 1.5 minutes. The breechblock was closed by an enlisted man.
.....	To determine time to fire 1 round, change mainspring, sear spring, firing pin, and extractor, mount and fire another round. 1 minute 37½ seconds. It required 2 trials to make the start, thus using 3 cartridges.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure, per square inch of bore.
			° ′	*Feet.*	*Right.*	*Pounds.*
June 5	246		2 16		0	
June 5	247		2 14		2	
June 5	248		2 15		1½	
June 5	249		2 16		1½	
June 5	250					
June 5	252					
June 5	253					
June 5	254					
June 5	255					
June 5	256					
June 5	257					
June 5	258					
June 5	259					

[Excessive

June 5	251					9, 33,462
June 5	260					9, 34,314
June 5	261					9, 64,600

Digitized by Google

? pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894—Continued.

ry at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind left and front, 10?, 3 miles an hour; barometer, 29.86; thermometer, 58°; humidity, 89.	Elevation by sight, 1,750 yards. Struck 100 yards in rear and slightly to the left. Elevation by sight, 1,700 yards. Struck target 7 feet below and 4½ feet right of center. Struck target 4 feet below and 6 feet right of center.	Aimed at the upper left corner of target.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	0.5	.....	7	2.1	.....	.....	3.65
.....	4.5	.....	2	.....	1.9	1.35	.....
.....	5	.....	3	.....	2.4	0.35	.....
.....	4	.....	5	.....	1.4	.....	1.65
.....	3	.....	5	.....	0.4	.....	1.65
.....	1.5	.....	4	1.1	.....	.....	0.65
0.5	.....	.....	1	3.1	.....	2.35	.....
.....	2.5	.....	7	0.1	.....	.....	3.65
0.5	.....	.....	1.5	3.1	.....	1.85	.....
.....	6	2	.....	.....	3.4	5.35	.....

Round 249 first to count on target.

Center of impact—	Feet.
Below	2.6
Left	3.35
Mean vertical deviation from center of impact	1.9
Mean horizontal deviation from center of impact	2.25
Mean deviation from center of impact	2.945

charges.]

.....	Service charge. Fired to obtain pressure.
.....	1 ounce rifle powder added to charge.
.....	4 ounces rifle powder added to charge. Blow back through primer. Shell wedged back tightly against breechblock, could not be moved by means of handles; handles began to bend. Sledge hammer and wooden drift used to start block, pressure being kept on the handles. Mechanism completely filled with powder residue. Mechanism taken apart and found to be in good condition, nothing broken or injured in any manner.
	Residue wiped from parts, assembled, and firing resumed at 3,000-yard target.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore.
			° ′	*Feet.*	*Right.*	*Pounds.*
June 5	262		4 45½		0	
June 5	263		4 47		4	
June 5	264					
June 5	265					
June 5	266					
June 5	267					
June 5	268					
June 5	269					
June 5	270					
June 5	271					
June 5	272					

[Excessive

June 7	273					4, 37,218
June 7	274					35,431
June 7	275					36,200
June 7	276					33,554

[Test with defec

June 9	277					
June 9	278					
June 9	279					

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792 pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894—C

racy at 3,000 yards.]

Wind. strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General re
Wind right and rear, 80°, 4 miles an hour; barometer, 29.85; thermometer, 58°; humidity, 89.	Struck 45 yards in front and 17 yards to the left.	Round 263 first t Round 265 miss; i Round 270 miss; : good line.

TARGET.

From center of target.				From center of impact.				
Vertical.		Horizontal.		Vertical.		Horizontal.		
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
3	.....	2	.....	.....	2.25	.....	2.1875	Center of impact Above ..... Right.....
.....	0.5	12.5	.....	.....	5.75	8.3125	.....	Mean vertical from center of i
.....	.....	.....	.....	.....	.....	.....	.....	Mean horizontal from center of i
3	.....	2	.....	.....	2.25	.....	2.1875	Mean deviation ter of impact...
3.5	.....	.....	2.5	.....	1.75	.....	6.6875	
.....	2	.....	2	.....	7.25	.....	6.1875	
16	.....	3	.....	10.75	.....	.....	1.1875	
.....	.....	.....	.....	.....	.....	.....	.....	
8	.....	4	.....	2.75	.....	.....	0.1875	
11	.....	14.5	.....	5.75	.....	10.3125	.....	

charges.]

Wind right and rear, 80°, 4 miles an hour; barometer, 29.85; thermometer, 58°; humidity, 89.	1 ounce of rifle powder added to charge. Case dished near choke.
	1 ounce of rifle powder added to charge. Case dished same as before.
	1 ounce of rifle powder added to charge. Dish 2 inches long near choke.
	Service charge. Case dished near choke.

tive cartridges.]

.....	The cartridge case was prepared by filing obliquely through the edge of the rim, so as to just show an opening to the interior at the junction of the head and wall. The slots are at the extremities of two diameters at right angles with each other. Cartridge placed in gun so that the solid part of the rim came opposite the extractor. There was quite an escape of gas, as a matter of course, covering nearly all the parts of mechanism with residue. Breechblock opened by 1 man after several trials. Case extracted easily. Block worked then without much difficulty.
.....	The cartridge was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other and each was half way between the primer and the rim. Breechblock opened by 1 man after several trials, but with considerably more difficulty than previous round.
.....	Service cartridge. Breechblock worked easily. Time not noted.

Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore.
			° ′	*Feet.*		*Pounds.*
June 9						

[Dust test.

June 9	280 to 284					

792 pounds), at Sandy Hook Proving Ground, May 25 to June 28, 1894—Continued.

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		The gun was taken to the blacksmith shop to be dusted without any part being cleaned in any degree. Care was exercised to avoid removing residue from the breech mechanism in handling the gun.

gun cocked.]

	The breechblock could not be moved at all by means of the handles. An effort was then made to open it by using a carpenter's mallet on the underside and putting a strain on the handles at the same time. This failed and a sledge hammer was tried in the same manner, using a piece of hard wood on the block. All efforts to move the block more than about one-sixteenth of an inch failed until everything was deluged with oil. After this was done it required from 10 to 15 minutes to open it. The sledge was used as above described, first to start the block and then to close it. Continuing thus, a little was gained each time, oil being used freely. The dust was gradually worked out of the mechanism, dropping on the platform in the form of mud. After getting the block well started it was worked back and forth by hand, still adding oil. In this manner it was finally fully opened. The bore was then sponged out to remove the one-half pint, more or less, of sand which it contained, and 5 rounds were fired. Time to open block and fire the 5 rounds, 38 minutes 39½ seconds.	The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable. The attached blue prints show the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. One blue print shows the apparatus at work, the other shows it at rest. The dust used was burnt sand from the proof butts. The passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry, and answered well for this purpose. After being dusted, the gun was remounted and the time to open the breechblock and fire the 5 rounds was noted.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pr per in
			By sight, yards.	*Feet.*	*Right.*	*P*
June 9	285		1,760		2	
June 9	286				3	
June 9	287		1,800		3½	
June 9	288					
June 9	289					
June 9	290					
June 9	291					
June 9	292					
June 9	293					
June 9	294					
June 9	295					
June 9	296					
June 9	297					

accuracy at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 30°, 11 miles an hour; barometer, 30.12; thermometer, 75°; humidity, 66.	Struck 70 yards in rear and 10 feet to left of target. Struck 50 yards in front and 6 feet left of the line, and ricochetted through 9 feet below and 4 feet left of center. Struck target 10 feet above, 4½ feet left of center.	Aimed at the upper left corner.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
9	.....	7.5	.....	2.9	.....	5.185	.....
5.5	.....	6.5	.....	.....	0.6	4.185	.....
9	.....	2	.....	2.9	.....	.....	0.315
9	.....	1.833	.....	2.9	.....	.....	0.482
1.5	.....	0		.....	4.6	.....	2.315
.....	0.5	1	.....	.....	6.6	.....	1.315
5	.....	0.5	.....	.....	1.1	.....	1.815
11.5	.....	0.5	.....	5.4	.....	.....	1.815
5	.....	1	.....	.....	1.1	.....	1.315

Miss; struck 50 yards in front and ricochetted over.

Center of impact—	Feet.
Above	6.1
Right	2.315
Mean vertical deviation from center of impact	3.12
Mean horizontal deviation from center of impact	2.082
Mean deviation from center of impact	3.751

Time to fire the 10 rounds, 1 minute 33½ seconds.

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Record of firing with Hotchkiss 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[For accuracy with rapidity at two 500-yard targets

Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch... bore.
			° ′	*Feet.*		Pounds
June 11	298					
June 11	299					
June 11	301					
June 11	302					
June 11	303					
June 11	305					
June 11	306					
June 11	307					
June 11	309					
June 11	311					
June 11	313					
June 11	315					
June 11	300					
June 11	304					
June 11	308					
June 11	310					
June 11	312					
June 11	314					
June 11	316					
June 11	318					
June 11	317					

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore.
			° ′	*Feet.*		*Pounds.*
June 12	319 and 320					
June 12	321					
June 12	322					
June 12	323					

[For rapidity with accu

			By sight, yards.		*Left.*	
June 13	324		1,000		1	
June 13	325		1,010		0	
					Right.	
June 13	326		1,010		1	
June 13	327		1,010		3	
June 13	328		1,010		4	
June 13	329					
June 13	330					
June 13	331					
June 13	332					
June 13	333					
June 13	334					
June 13	335					
June 13	336					
June 13	337					
June 13	338					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	The first and second blowback cartridges were fired and the block worked well. In the third blowback the primer exploded, but failed to explode the charge.	The blowbacks were secured by unloading the requisite number of rounds, decapping the shells, and thinning the metal of the primers. The shells were then recapped and the charges replaced.
.....	Service charge	
.....	Another blowback was then prepared and fired at first attempt, followed by a service round, both without difficulty.	
.....	Time to fire 2 blowbacks, failure of third, and 1 service round, 1 minute 21¾ seconds. To fire 1 blowback and 1 service round, 12 seconds. To fire 3 blowbacks and 2 service rounds, 1 minute 33¾ seconds.	

racy at 1,000 yards.]

Wind from front and left, 80°, 8 miles an hour; barometer, 30.25; thermometer, 63°; humidity, 74.

Miss; low, 21½ feet left .....

Struck target 3 feet 9 inches below, 25½ feet left of center.

Struck target 3 feet below and 18½ feet left of center.

Struck target 12 feet left of center.....

Struck target 5½ feet below and 7 feet left of center.

Aimed at the upper left corner. The sight had to be adjusted after each shot.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	2	.....	2	0.222	.....	3.139	.....
.....	2	.....	4	0.222	.....	1.139	.....
.....	1.25	.....	4.25	0.972	.....	0.889	.....
.....	1	.....	6	1.222	.....	.....	0.861
0.5	.....	.....	6	2.722	.....	.....	0.861
.....	4	.....	6	.....	1.778	.....	0.861
.....	5	.....	6	.....	2.778	.....	0.861
0.5	.....	.....	5	2.722	.....	0.139	.....
.....	5.75	.....	7	.....	3.528	.....	1.861

Miss .....

Center of impact—	Feet.
Below	2.22
Left	5.14
Mean vertical deviation from center of impact.....	1.796
Mean horizontal deviation from center of impact	1.179
Mean deviation from center of impact.....	2.149

Time to fire the 10 rounds, 2 minutes 36½ seconds.

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Record of firing with Hotchkiss 6-pounder rapid-fire gun (caliber 2.244 inches, weight

[For rapidity with accuracy at 500 and 1 000 yard

Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore
			By sight, yards.	*Feet.*	*Right.*	*Pounds*
June 15	339		1,000		4	
June 15	340		600		0	
June 15	341					
June 15	343					
June 15	345					
June 15	347					
June 15	349					
June 15	351					
June 15	353					
June 15	355					
June 15	357					
June 15	359					
June 15	342					
June 15	344					
June 15	346					
June 15	348					
June 15	350					
June 15	352					
June 15	354					
June 15	356					
June 15	358					
June 15	360					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind right and rear, 45°, 10 miles an hour; barometer, 30.22; thermometer, 83°; humidity, 43.	Fired at 1,000-yard target. Struck target 4 feet below, 11½ feet left of center. Fired at 500-yard target. Struck target 5 feet below center.	Aimed at the upper left corner (1,000 yards). Aimed at bull's-eye (500 yards). Sight adjusted for each shot at each target.

TARGET 1,000 YARDS.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
5	.....	.....	3.5	5.167	.....	2.677	.....
2.667	.....	.....	6.25	2.834	.....	.....	0.073
1	.....	.....	8	1.167	.....	.....	1.823
.....	1.5	.....	2.833	.....	1.333	3.344	.....
.....	0.5	.....	7	.....	0.333	.....	0.823
.....	1	.....	7	.....	0.833	.....	0.823
.....	3.5	.....	6	.....	3.333	0.177	.....
.....	3.5	.....	8.833	.....	3.333	.....	2.656

Miss .....
Miss .....

Center of impact—	Feet.
Below	0.167
Left	6.177
Mean vertical deviation from center of impact	2.292
Mean horizontal deviation from center of impact	1.550
Mean deviation from center of impact	2.766

TARGET 500 YARDS.

.....	5	.....	1	.....	2.394	0.139	.....
.....	3.875	.....	0.25	.....	1.269	0.889	.....
.....	2.667		0	.....	0.061	1.139	.....
.....	2.75	.....	0.75	.....	0.144	0.389	.....
.....	2.333	.....	0.167	0.273	.....	0.972	.....
.....	2.083	.....	2.75	0.523	.....	.....	1.611
.....	2.25	.....	3.833	0.356	.....	.....	2.694
.....	1.583	.....	0.417	1.023	.....	0.722	.....
.....	0.917	.....	1.083	1.689	.....	0.056	.....

Miss .....

Center of impact—	Feet.
Below	2.606
Left	1.139
Mean vertical deviation from center of impact	0.859
Mean horizontal deviation from center of impact	0.957
Mean deviation from center of impact	1.286

Time to fire the 20 rounds, 5 minutes 22¾ seconds.

The detachable point of firing pin was found broken. It was not unserviceable. A new point was substituted. The face plate was found slightly upset, and cracked a little around the hole for the firing pin. "The upset" was on the rear face, the metal having been forced back into the slot in which the firing pin plays. Dressed down by a machinist.

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Date.	No. of fire.	Kind of projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Deflection points.	Pressure per square inch of bore.
			° ′	*Feet.*		*Pounds.*
June 21	361 to 365					

[Rust test, gun

June 26						
June 28	366 to 370					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	In each of these 5 rounds the block had to be opened by using a mallet on the handle, and had to be closed by 1 man working on the handle and another using a mallet on the bottom of the block. No oil or water used. Time to open block and fire 5 rounds, 22 minutes 47 seconds. In sledging the block open one blow of the sledge accidentally missed the wooden drift and struck the rear under edge of the breech-block, slightly burring the metal. Burr removed.	Owing to the lack of uniformity in the conditions of the different breech mechanisms when subjected to the first dust test, it was considered advisable to repeat this test. In the second dust test all the parts of the different mechanisms were thoroughly washed with hot water and soap; they were then carefully dried and lightly oiled. When subjected to the blast of dust the gun was not cocked. The arrangement for dusting and the material used were the same as in the first dust test. The gun was subjected to a blast of dust for 8 minutes. The block could not be opened by hand. A mallet was used on the handle and failed. A sledge and block of wood were then used on the block, and in this manner it was opened. It was then opened and closed a number of times by hand, with the assistance of a mallet, and the dust worked out of the mechanism in the endeavor to manipulate it by hand alone. The dust was removed from around the extractor. The bore was wiped out with dry waste.

not cocked.]

		The breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap. The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water, by weight. It was suspended with the axis vertical and was lowered into the solution just enough to cover the breech mechanism. Before immersing, a soft wood plug, wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber. The main bolt cut in its bearing in opening during the second dust test. The bolt and its bearing were dressed before the gun was immersed. Gun was immersed at 4:12 p. m. Gun taken out at 4:37 p. m. Gun in solution 25 minutes.
	The breechblock could not be opened by hand, nor by using a mallet on the handle. It was opened by using a sledge and copper drift. A cartridge was inserted but the mechanism failed to work. It was dismantled, roughly cleaned, replaced, and the 5 rounds fired. Time to open block and fire 5 rounds, 35 minutes.	Firing conducted in the presence of the Ordnance Board. Present: Maj. F. H. Phipps, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt W. Crozier, Ordnance Department. M. F. Harmon, First Lieutenant, First Artillery, U

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HOTCHKISS 6 PDR. RAPID-FIRING GUN

BODY OF GUN

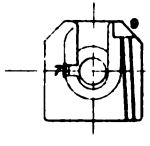

FIG. 3.

FIG. 1.

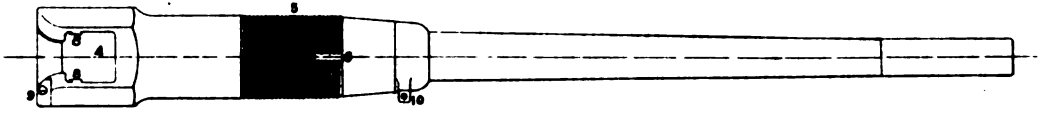

FIG. 2.

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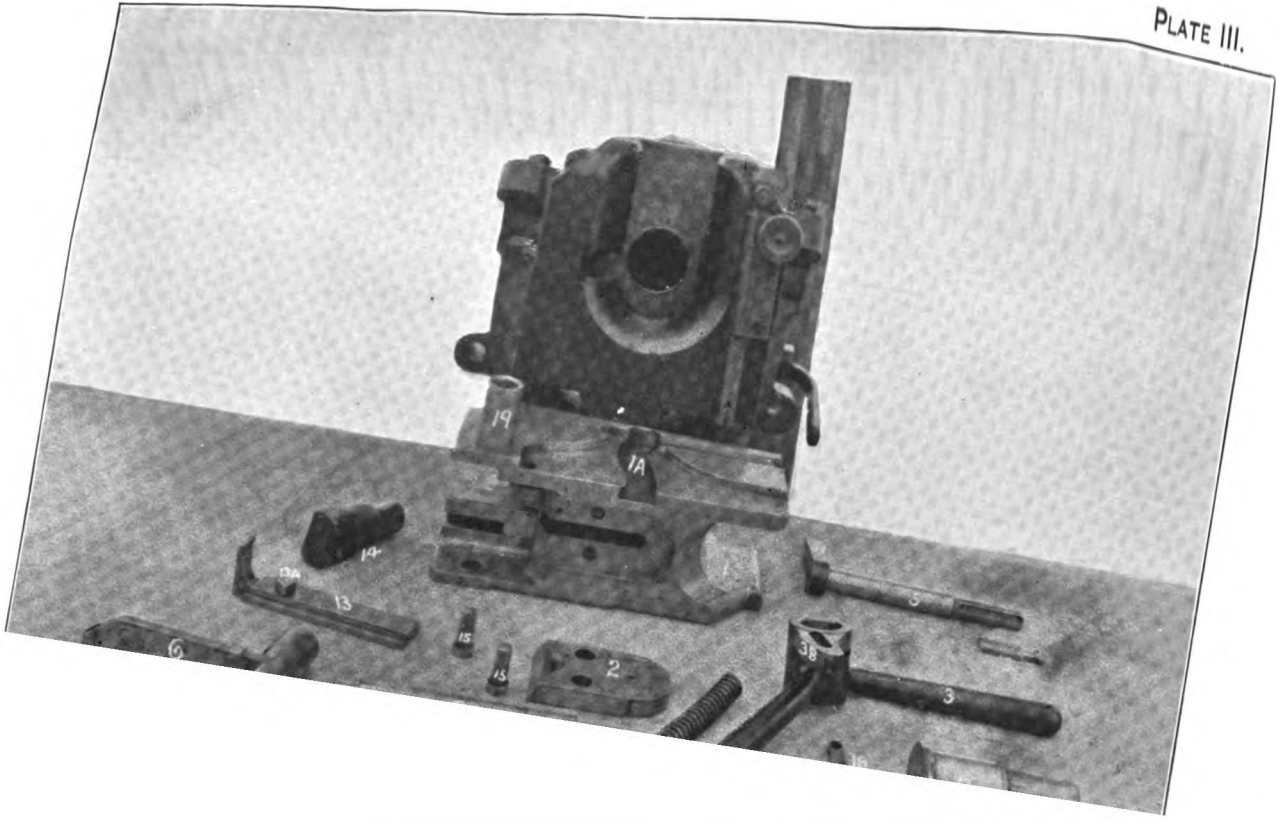
PLATE III.



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HOTCHKISS 6 PDR. RAPID - FIRING GUN

SIGHTS

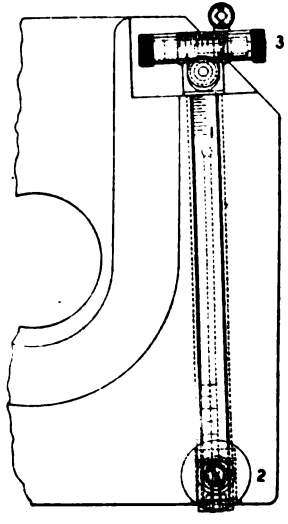
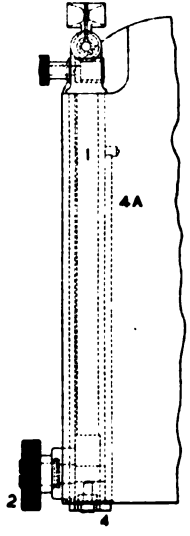


FIG. 1.



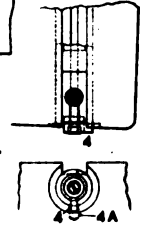


FIG. 3.

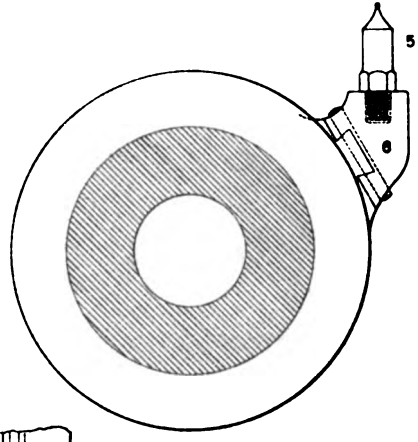


FIG. 2.

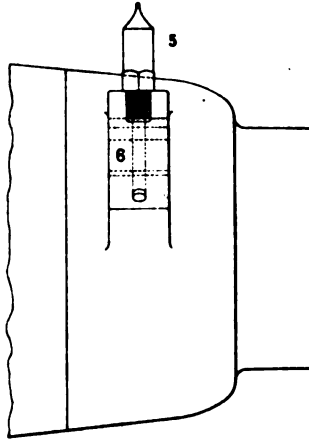


FIG. 4.

Appendix 33 B, 1894.

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AMMUNITION

COMMON SHELL

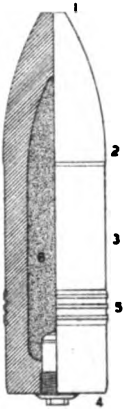


FIG. 1.

STEEL SHELL

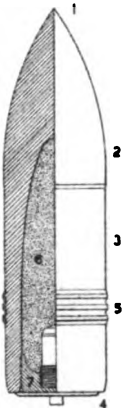


FIG. 2.

CASE SHOT

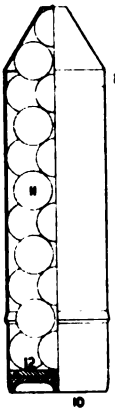
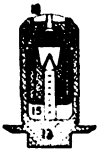


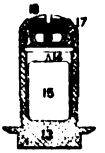
FIG. 3.

BASE PERCUSSION FUZE



POSITION OF PLUNGER BEFORE FIRING

FIG. 4.



POSITION OF PLUNGER DURING FLIGHT

FIG. 5.

PRIMER

FIG. 6.

DRILL CARTRIDGE

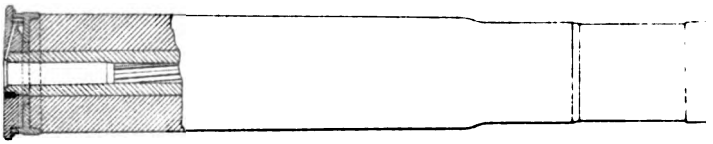


FIG. 7.

COMPLETE CARTRIDGE

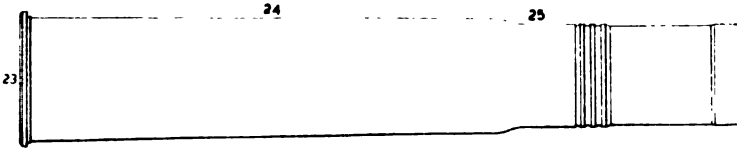


FIG. 8.

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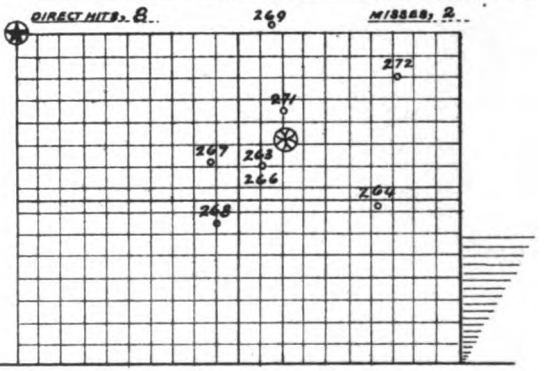
TARGET 3000 YARDS FROM GUN JUNE 5TH 1894.

DIRECT HITS, 8. 269 MISSES, 2.



TARGET 30'X40'

ROUND NO.	MILES PER HOUR.	DIRECTION.
263	4	Right rear 80°
264	"	" " "
265	"	" " "
266	"	" " "
267	"	" " "
268	"	" " "
269	"	" " "
270	"	" " "
271	"	" " "
272	"	" " "

4.81
4.65
6.70

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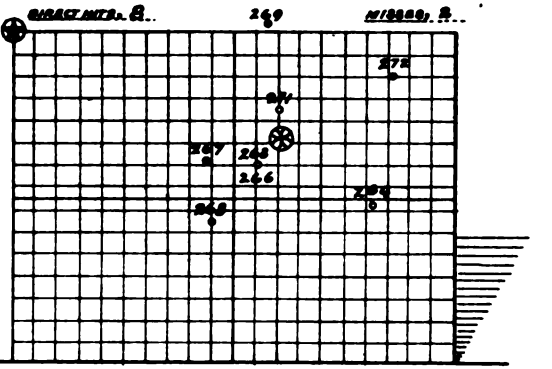
TARGET 3000 YARDS FROM GUN June 5th 1894.

DIRECT HITS. 2 ... 269 ... MISSES. 8 ...



TARGET 30'x40'

ROUND NO.	MILES PER HOUR.	DIRECTION.
263	4	Right rear 80°
264	"	" " "
265	"	" " "
266	"	" " "
267	"	" " "
268	"	" " "
269	"	" " "
270	"	" " "
271	"	" " "
272	"	" " "

4.81
4.65
6.70

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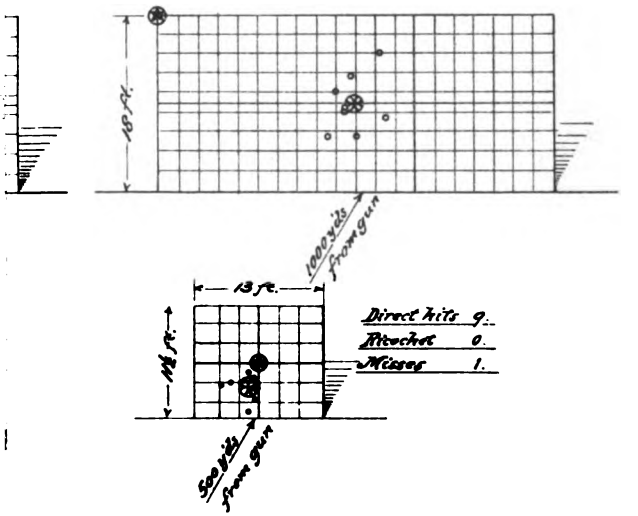
Alternating shot by shot on targets.

...nc. June 15/94. Rounds 341 to 360 inc.

... Direct hits 8. Ricochet 0. Misses 2.



... 0.86 ft. ... 2.29 ft.

... 0.96 ft. ... 1.55 ft.

... 1.29 ft. ... 2.77 ft.

... 20 rounds = 5 m. 22⅘ sec.

5°. ... 10 miles per hour, from right and rear 45°.

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TEST OF 6-POUNDER MAXIM-NORDENFELT RAPID-FIR

(8 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL, GOVERNORS ISLAN
NEW YORK HA
New York City, Octobe

SIR: The following report of a 6-pounder Maxim-Nord fire gun is respectfully submitted:

DESCRIPTION.

The accompanying plates 1 to 4, inclusive, illustrate su manner in which the gun is constructed. The material us tions of the gun is oil-tempered steel.

The mechanism consists of the following parts, 15 in nu

(Plate I.)

a. Action lever.
b. Action cam.
c. Breechblock.
d. Wedge.
e. Extractor.
f. Tappet lever.
g. Trigger lever.
h. Mainspring.
k. Firing pin.
l. Action pin.
m. Extractor axis.
n. Spring pin.
o. Spring for *n.*
p. Locking pin for
r. Handle for *n.*

(Plate II.)

Fig. I. Represents a vertical section of the gun.
Fig. II. A plan of the gun and development of the rifli

(Plate III.)

Fig. III. A vertical section of the breech when closed.
Fig. IV. A vertical section of the breech when open.
Fig. V. A horizontal section of the breech when closed.

(Plate IV.)

Fig. VI. An elevation of the breech when closed, showing
Fig. VII. An elevation of the breech when open.
Fig. VIII. A plan of the breech when closed.
a. Action lever has a vertical one-third circle motion from
It is one piece with the main axis.

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by the action lever.

c. Breechblock carries the firing pin, mainspring, tappet lever, and trigger lever. The firing pin has beveled projections or cocking lugs on its base for the wedge to act on, and in the underpart there is a groove in which the trigger lever catches and retains it. The mainspring is flat, of great power and strength. The trigger lever pivots on its pins, and its motion is regulated by a safety lug moving round a corresponding lug on the wedge. The tappet lever, actuated by the wedge, strikes the trigger lever, so catches and retains the firing pin.

d. The wedge has a vertical motion in the breech. On its lower end is the action pin, which fits in the slot of the action cam.

e. The extractor axis is one with the "drill stop." The extractor works on both sides of the cartridge case, and has two projections which abut on the lower part of the breechblock.

ACTION OF THE MECHANISM.

The action of the mechanism is as follows, supposing the gun to have just been fired, and therefore the action lever in its most forward position:

LEVER MOVED BACK.

First. The action lever carries the action-cam slot over the action pin in the part which is concentric to its own motion, and therefore no movement of the mechanism takes place.

Second. The part of the action-cam slot, which is not concentric to its own motion, now engages the action pin, forcing the wedge down, which, acting on the cocking lugs of firing pin, forces it back and extends the main or firing spring. When the firing-pin lug is clear of the trigger lever, the wedge bearings act on the tappet lever and force up the trigger lever, which catches and retains the firing pin.

Third. The action pin, having reached the end of the action-cam slot, the action lever still moving back causes the breechblock to rotate and fall back to the rear. In the beginning of this movement the projections on the extractor have been slowly forced forward by the turning of the breechblock, and the empty cartridge case is thus slowly started, and at the latter part of this movement the projections on the extractor get a much quicker motion forward, and the extractor thus throws the empty cartridge case rapidly to the rear. The action lever is now at its furthest position to the rear.

LEVER MOVED FORWARD.

First. The breechblock is brought up and carried forward, pushing a fresh cartridge into the barrel.

Second. The cartridge being quite home, the action-cam slot engages the action pin in the part of the slot which is not concentric, and forces the wedge up into position; the action pin then passes into the concentric portion of the action-cam slot.

Third. The forward motion of the lever continuing, the end of the trigger lever comes in contact with the trigger.

The "drill stop" is placed on the right side of the breech and keeps the action lever in its place. Firing the gun is effected by pulling the trigger, which is protected by a guard.

The gun can not be fired before the breech is secured by the wedge—

First. As the inclined surface inside the wedge is formed in such a

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bearing surface. If the trigger is pulled before the bree the cocking lugs on the firing pin strike on the inclined s wedge, and the point can not strike the cap of the cartrid

Second. The safety lug on the trigger lever is behind th ing lug on the wedge until the wedge is fully home, and t trigger lever consequently can not be forced to release before the breech is secured.

MOUNTING AND DISMOUNTING THE MECHANISM.

Dismounting.

First. Place the drill stop in the position marked for t mechanism.

Second. Move the lever to the rear as far as possible.

Third. Withdraw the lever completely, a man holdi beneath the mechanism in order to receive it.

Fourth. Place the mechanism on a support, with its le ward, unscrew the action pin, and remove the action cam

Fifth. Turn the mechanism with the wedge downward, breechblock out backward.

Sixth. Ease the mainspring by pulling the trigger leve becomes free; turn the tappet trigger, so that it is out the mainspring, which remove by gently tapping its lowe the left with the hammer-like handle of the action pin.

Seventh. Remove the firing pin and tappet lever.

Mounting.

The mounting or putting together the mechanism is pe reverse order to that of dismounting.

First. Insert the firing pin and trigger lever.

Second. Place the tappet lever in the same position mainspring was taken out.

Third. Insert the mainspring from behind with hal underneath its holder on the breechblock, and drive it fo action pin as far as it has to go, and then to the right till

Fourth. Place the wedge on end, with the slot up; sl into the wedge, forcing it hard down with both hands, th the mainspring till the firing pin is caught and retained l lever.

Fifth. Turn the mechanism, with its left side downwa action cam, and screw in the action pin, and let the end stop underneath the lug on the right-hand side of the which will thereby prevent it from sliding down.

Sixth. Lift the mechanism and place it in the breech i that it is in when the breech of the gun is fully open.

Seventh. Insert completely the action lever in a positio ing to that of the mechanism, viz, in its extreme rear pos

Eighth. Turn the handle of the action pin so as to all to slide.

Ninth. Lock the mechanism by moving the lever into it ward position.

Tenth. Lock the lever by placing the "drill stop" in t position.

NOTE.—The "drill stop" placed in the position marke be taken out; the extractor is then free to be removed.

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CARE REQUIRED IN ORDER TO PRESERVE THE GUNS IN EFFICIENT WORKING ORDER.

The guns must be kept clean, free from rust and undefaced.

Brick dust or substances of like nature must never be used on any part of the gun.

The parts of the mechanism must not be scraped or roughened in any way, but must be kept lightly oiled as a protection from rust.

After firing every part of the gun must be thoroughly cleaned, the mechanism dismounted, washed with fresh water and soap, well dried, and then lightly oiled.

When all parts of the gun are cleaned, dried, and oiled, the mechanism may be mounted, and the gun should be protected from the weather.

SIGHTS.

(Plate V.)

The rear or tangent sight is of steel, marked in yards, and fitted with a deflection leaf graduated in degrees; it slips into a gun-metal socket on the left of the gun, placed at an angle with the plane of the axis which corrects the sight for permanent drift. The sight is raised and lowered by means of a milled screw in the socket which goes into a ratchet on the sight, and is provided with an automatic brake, which prevents the elevation being altered by the shock caused by firing.

The foresight is of steel, and is screwed into its place on the gun. It differs from the one shown on Pl. IV in that the top is a full cone instead of as shown.

AMMUNITION.

(Pl. VI.)

(*Nomenclature.*)

The powder used for these guns is the Nordenfelt hexagon. It is a small pellet powder of six sides, with indented ends, and of considerable density, viz, 1.82. The service charge, with all descriptions of projectiles except case shot, is 1 pound 15 ounces.

The cartridge case is of brass, solid drawn, the base and body being of one piece. In shape it is slightly conical, to insure easy extraction.

The powder is shaken down into the cartridge case so as always to occupy the same space; this insures great uniformity in velocity.

The service shell is made of steel; it is furnished with a copper driving band of the usual type, and has a shallow groove or cannelure near the base into which the cartridge case is indented at three points. The base piece is of mild steel, and is screwed into the shell; it is optional with the manufacturers whether a base piece is employed or the base formed in one with the body. The base is bored and screwed to receive the fuse. The head is pointed and is struck with a radius of 6.555 inches. The interior of the shell is varnished; the exterior is painted black with a white band around the head.

The Hotchkiss fuse.

The body of the Hotchkiss fuse is of gun metal threaded to screw into the base of the shell, and is fitted with a percussion pellet, gun-metal screwed cap, screwed plug, and a copper detonating cap. The percussion pellet consists of a brass casing filled with lead in which a hard drawn brass wire needle (roughened) is embedded. The cap is filled with detonating composition and covered with a thin brass disk.

The shock of discharge sets the pellet back along the needle, leaving the whole free to fly forward against the cap on graze or impact.

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The 6-pounder cartridge case contains 1 pound 15 ou
powder, and the shell is filled with 4 ounces of quick fine

Dimensions of ammunition for a 6-pounder.

The case:
- Diameter over base .....
- Diameter at neck .....
- Total length .....

The shell:
- Diameter over body .....
- Diameter at swell .....
- Diameter at driving band .....
- Length .....
- Weight, empty .....

The shell is inserted in the neck of the cartridge case
by three indents. A felt wad is placed in the case betw
of the fuse and the powder.

To protect the cap against being accidentally struck, a
clip is placed on the base of the cartridge; a dome is
center of it to cover the cap.

Range table.

[Charge, 1 pound 15 ounces; weight of projectile, 6 pounds; M. V., 1,870 f

Yards.	Elevation.	Angle of descent.	Increase or decrease of range due to 5'.	Time of flight.	Dangerous zone for a 6' object.	Remaining velocity.
	° ′	° ′	*Yards.*	″	*Yards.*	*Ft. secs.*
100	0 5	0 6	100	.18	.....	1,804
200	0 10	0 12	100	.35	.....	1,741
300	0 15	0 18	100	.52	.....	1,680
400	0 20	0 24	100	.7	.....	1,6 01
500	0 26	0 31	83	.88	222	1.561
600	0 32	0 38	83	1.07	182	1.504
700	0 39	0 48	71	1.26	143	1,448
800	0 46	0 58	71	1.46	118	1,395
900	0 53	1 9	71	1.66	100	1,345
1,000	1 0	1 21	71	1.88	87	1,296
1,100	1 7	1 33	71	2.1	74	1.251
1,200	1 15	1 48	62	2.33	64	1,208
1,300	1 23	2 6	62	2.57	54	1,169
1,400	1 31	2 24	62	2.83	47	1,132
1,500	1 39	2 42	62	3.1	42	1,097
1,600	1 48	3 0	55	3.38	38	1,066
1,700	1 57	3 18	55	3.67	35	1,038
1,800	2 8	3 37	46	3.97	31	1,014
1,900	2 19	3 56	46	4.27	29	9?5
2,000	2 31	4 17	42	4.57	27	979
2,100	2 43	4 38	42	4.88	24	9?3
2,200	2 55	5 0	42	5.19	23	9?7
2,300	3 8	5 23	38	5.5	21	931
2,400	3 21	5 46	38	5.82	19	916
2,500	3 34	6 10	38	6.14	18	901
2,600	3 47	6 37	38	6.46	17	887
2,700	4 0	6 4	38	6.78	16	8?3
2,800	4 14	7 32	36	7.12	15	8?9
2,900	4 28	8 0	36	7.46	14	846
3,000	4 43	8 30	33	7.8	13	8?3
3,100	4 58	9 2	33	8.15	13	820
3,200	5 13	9 36	33	8.5	11	807
3,300	5 28	10 11	33	8.85	11	795
3,400	5 44	10 47	31	9.2	10	783
3,500	6 0	11 23	31	9.58	10	772
3,600	6 16	12 0	31	9.98	9	761
3,700	6 33	12 37	29	10.38	8	751
3,800	6 50	13 15	29	10.8	8	741
3,900	7 8	13 54	27	11.22	8	732
4,000	7 27	14 36	26	11.64	7	724

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parts of the breech mechanism, their strength, simplicity, and certainty of action, to be noted; also the ease, safety, and certainty of the breech mechanism as a whole. Note especially the action of the firing pin and extractor, and the maximum outward position of the cartridge when it can be pushed home by the breechblock. During this examination 50 rounds to be fired at will.

VELOCITY.

Five rounds to be fired for velocity with full charges.

ACCURACY.

Ten rounds to be fired at each range of 1,000 yards, 1 mile, and 3,000 yards, the same conditions of aiming being repeated at each round, and the mean deviations determined.

RAPIDITY.

Determine number of rounds that can be fired in 5 seconds, 3 trials; also number of rounds that can be fired in 1 minute, 3 minutes, and 5 minutes, respectively, and finally the time required to fire 100 rounds, noting carefully during the firing, and especially at end of each 25 rounds, the condition of the gun as regards heat, and ease and certainty of action.

Two detachments of men alternating every 25 or 50 rounds, as may be thought advisable.

RAPIDITY WITH ACCURACY.

Fire 10 aimed shots as rapidly as possible at the 1,000-yard and 1-mile targets; also 10 aimed shots at targets in same line and ranges of 500 and 1,000 yards alternately; also 10 aimed shots alternately at targets at about 500 yards range, placed about 75 feet apart.

DUST.

The mechanism to be exposed to a blast of fine dust in such manner as to insure its being uniformly and equally covered with the dust, after which 20 rounds to be fired as rapidly as possible.

EXCESSIVE CHARGES.

The gun to be fired with 5 charges giving gradually increasing pressures up to 45,000 pounds per square inch if such pressures are attainable.

DEFECTIVE CARTRIDGES.

The gun to be tested with defective cartridges in the same manner as is usual in the trial of small arms.

Any rounds that may remain after the above tests to be expended in such manner as may be deemed best by the board as a result of the circumstances developed; the last 5 rounds to be fired after the mechanism of the gun has been rusted in a thorough and uniform manner.

The test, in accordance with the programme, was commenced on May 1 last.

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The length of the gun from the seat of the head of the cartridge case is 42.3 calibers. The gun is fired by a trigger. The action of the mechanism in manipulation and deliberate firing was found to be satisfactory, except that when the breechblock is closed smartly and the lever released, the instant the breechblock strikes, the reaction will nearly always reopen it.

The device for clamping the gun is not convenient. The shape of the guide, which projects from the rear of the gun, causes the point of the shell in loading to strike the lower portion of the chamber, burring it considerably; to remedy this and to facilitate loading a small triangular piece was cut from the upper corner of the guide by the company's representative at his suggestion.

The cartridge can be forced home by the breechblock when it is short of its seat in the chamber $5\frac{1}{16}$ inches.

The hydraulic buffers absorb in a great measure the energy of recoil of the gun, which they limit to 4 inches. After firing, the gun returns to the firing position without shock or rebound.

Starting with the breechblock closed, the breech mechanism was removed and dismantled by one man (the representative of the gun) in 25 seconds, using no tools whatever save parts of mechanism. At the first trial two parts were overlooked; upon a second trial all were removed in $31\frac{3}{4}$ seconds. They were replaced, and the motion of firing executed in 1 minute and 9 seconds.

In action the parts most liable to injury are the mainspring, sear spring, firing pin, and extractor; to ascertain the time required to remove these parts and resume firing, one shot was fired, the block removed, the four parts changed, and a second shot fired in 3 minutes and $33\frac{3}{4}$ seconds.

In this operation of dismantling some difficulty was experienced in removing the action pin. This pin screws into the block; it had previously been readily removed and replaced by hand. On this occasion a wrench was needed. On removal it was found to be slightly bent, and the great length of time required for this operation as compared with the time required for dismantling and assembling the entire mechanism is accounted for. The weight of the breech mechanism complete is $77\frac{5}{16}$ pounds.

VELOCITY.

The maximum velocity attained in firing 5 rounds was 1,880 foot-seconds; the minimum, 1,857 foot-seconds; and the mean 1,871 foot-seconds.

ACCURACY.

At 1,000 yards range, the mean vertical deviation from the center of impact of 10 shots was 1.85 feet, the mean horizontal deviation 0.7 foot, and the mean deviation 1.97 feet.

One sighting shot was used and there were no missfires. The sight was set at 900 yards.

At 1 mile range there was but 1 sighting shot. Of the 10 shots fired at the target there were no misses; the deviations were as follows: Mean vertical, 2.44 feet; mean horizontal, 1.65 feet; mean deviation, 2.94 feet. Sight set for 1,600 yards.

At 3,000 yards there were 7 sighting shots. Of the 10 fired at the target with sight set for 2,700 yards, there were no misses, and the following deviations in feet: Mean vertical, 5; mean horizontal, 4.04; mean deviation, 6.43.

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In 5 seconds the number of rounds fired was: At the first trial, 3; at the second trial, 3; at the third trial, 2.

The number fired in 1 minute was 20; in 3 minutes, 65, the 20 fired in one minute being determined by noting the number fired in the first minute of the 3. In the 3-minute test the officers alternated in loading and firing at the end of 1.5 minutes.

One hundred rounds were fired in 4 minutes and 41 seconds. In this firing the ammunition was placed on a table in the rear of, and as close to the piece as possible without interfering with the handling of the gun. Two officers loaded and fired, exchanging places after each 25 rounds. They were assisted in the handling of the ammunition by one enlisted man. After the thirty-seventh round the buffer cylinder leaked slightly and was tightened. In rapid firing the breechblock, when opened quickly, caught the empty case by the rebound of the block and stopped the case unless the lever was held down hard at the completion of the stroke; otherwise the mechanism worked satisfactorily throughout. The heat generated by firing was so great that rosin melted on chase after fiftieth round.

RAPIDITY WITH ACCURACY.

In firing for rapidity with accuracy at 1,000 yards 1 sighting shot was used, then 10 shots at target without a miss. The deviations, in feet, were as follows: Mean vertical, 1.75; mean horizontal, 1.55; mean deviation, 2.34. Time occupied in firing 10 shots, 2 minutes 37½ seconds.

At 1 mile range there were 3 sighting shots. Of the 10 shots at target, all hit. The deviations in feet were: Mean vertical, 2.77; mean horizontal, 1.66; mean deviation, 3.24.

Time occupied in target shots, 1 minute 48⅝ seconds. A new mainspring was put in after the third sighting shot.

At 2 targets at 500 yards range, placed 80 feet apart, there were fired in all 3 sighting shots, 2 at No. 1 and 1 at No. 2 target; then 10 shots at each target, alternating at every shot. There were no misses at either target of the 20 rounds fired. The deviations were: For Target No. 1, mean vertical, 0.88 feet; mean horizontal, 0.68 feet; mean, 1.11 feet. For Target No. 2, mean vertical, 0.84 feet; mean horizontal, 1.06 feet; mean, 1.36 feet.

Time for firing 20 rounds, 3 minutes 28 seconds. The sight was adjusted after eighth round. In the firings with this gun the drift scale shows a tendency to move slowly to the left, due probably to an inclination of the muzzle to the right.

At targets placed in same line, but one at 500 and the other at 1,000 yards range, 2 sighting shots were fired at each target; afterwards 20 shots were fired alternately at the targets without a miss. The deviations in feet were: For the 500-yard target, mean vertical, 1.1; mean horizontal, 1.46; mean, 1.83. For the 1,000-yard target, mean vertical, 1.2; mean horizontal, 1.44; mean, 1.87. Time occupied in firing 20 shots, 6 minutes. The plotted targets are inclosed, Plates VII and VIII.

DUST.

The attached blue print shows the method adopted for dusting the mechanism. A lead pipe "A" leads from the pine box "C" to the hand bellows in the blacksmith shop. The dust used was burnt sand taken from the proof butts. This sand is converted into something like

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As it pulverizes readily when dry, it answered well for
gun was subjected twice to this test.

At the first test the gun was not cleaned after firing
tridges, and care was exercised to avoid removing re
mechanism in handling. It was subjected to a steady b
8 minutes, 2 men working the bellows as uniformly as
gun was cocked.

The gun was then remounted and the time require
block, and fire 5 rounds was found to be 3 minutes, 27¼

After the first of these 5 rounds the breechblock
difficulty, but it was necessary to use some water before
easily; two or three snappings of the firing mechan
necessary to free the dust from around the firing pin.

In the second test all the parts of the mechanism w
washed with hot water and soap, then carefully dried, an
The gun was then subjected to a blast of dust for 8 min
the gun was not cocked. The block was opened withou
was half closed, and opened rapidly several times to jar
the mechanism, and a bunch of dry waste was forced tw
bore. In attempting to insert a cartridge for firing it
the breech could not be closed, and it was necessary to
cartridge and remove the dust from the seats for the ex
done, the 5 rounds were fired without difficulty, no oil
used throughout, the time occupied in opening the b
5 rounds being 4 minutes and 12 seconds. The progra
the firing of 20 rounds after dusting, but this number w
because of the scarcity of ammunition.

EXCESSIVE PRESSURES.

To ascertain the effect of abnormal pressures, 6 rou
commencing with the service charge. The quantities
added, and the pressures per square inch corresponding,
Service charge, pressure 34,800 pounds; 1 ounce added,
2 ounces, 38,031; 2½ ounces, 39,982; 3 ounces, 43,956; 3
pounds. With the addition of 3 ounces a slight blowba
After the round with the addition of 3¼ ounces, the fi
fouled by residue that it was necessary to employ a mo
remove it from the block. The cap from primer was fo
into hole for firing pin, wedging it. The mainspring w
set. Otherwise no difficulty was experienced in this te
mechanism was cleaned, oiled, and replaced, and 1 rou

DEFECTIVE AMMUNITION.

To ascertain the effect on the breech mechanism of fi
tive cartridges the latter were weakened by filing thr
the head, making openings at the extremities of two dia
angles with each other, by sawing through the head
angles and each half way between the primer and rim,
"blowbacks," by trimming down thin the primers, so th
would cut through. In the first case the cartridge was
gun that the solid part of the rim came opposite th
firing there was quite an escape of gas as was expected,
block opened easily.

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Under the second conditions, after firing, the breech block also opened without difficulty. A service cartridge was next fired at first attempt, showing all the parts in working condition. The time occupied in firing the 3 shots was 50 seconds.

With the blowbacks greater difficulty was experienced, as there were 6 missfires with the first cartridge. A sound cartridge also missed fire, showing some trouble with the firing pin The mechanism was dismantled, and the old pin, fouled with residue and slightly upset, removed. With a new pin the second blowback was fired at first attempt.

The primer of the third blowback failing to explode after 2 attempts, the cartridge was removed and a bucket of water was thrown over the block to soften the residue around the pin.

After 3 more failures with the defective and 1 with a sound cartridge, the breech mechanism was dismantled, and the new pin found in the same condition as its predecessor, fouled with residue and upset.

Another new firing pin was substituted. The blowback failed after three attempts. A sound cartridge was introduced, and fired at first blow. The primer of the blowback again failing, although well indented, was evidence that it had been rendered defective in the thinning process. A new blowback having been prepared, it was fired without a missfire. With a service cartridge next tried, there resulted 3 missfires. The block was dismantled, the parts washed, reassembled, and a second unsuccessful attempt made to fire the same cartridge. The block opened with difficulty. The mechanism was again taken apart and thoroughly cleaned. It was found that the force of the powder gas against the firing pin had driven the mainspring back against the block, burring the spring and indenting the block.

After removing the burr and assembling the mechanism, a service cartridge was fired without missfire.

The block stuck again, probably for want of lubricant, but opened readily after a pail of water had been emptied over it.

A small spring in the trigger, found broken, was not replaced, not being necessary. The time occupied in firing 3 blowbacks and 2 service or sound cartridges was 41 minutes and 13 seconds.

RUST.

The gun, not cocked, was immersed in a solution of 15 per cent sal-ammoniac and 85 per cent water, by weight. Suspended vertically, it was lowered far enough to cover the breech mechanism, and remained immersed 25 minutes. Before it was put in the rusting solution, it had been cleaned by washing with hot water and soap. A soft plug of wood wrapped with a piece of cartridge bag material smeared with cosmoline, was driven into the breech of the gun to prevent rusting of the chamber. After removal from the bath it was allowed to rust for 48 hours. In opening the block the mechanism was first oiled, one man kept a strain on the handle, while another used a brass drift and hammer on the block.

It was not necessary to dismantle the mechanism until after the firing of 5 rounds. When taken apart the only injury was to the main shaft and its journal, which were only slightly burred. The burrs were removed by the representative of the gun.

Time occupied in opening block, 5 minutes; in opening block and firing 5 rounds, 6 minutes 25 seconds.

The loading and firings were done by Lieut. M. F. Harmon, First Artillery, and Lieut. F. P. Peck, Ordnance Department.

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Weight	pounds	756
Caliber	inches	2.244
Length	calibers	$42\frac{3}{10}$
Weight of breech mechanism	pounds	$77\frac{5}{10}$
Number of parts of breech mechanism		15
Time to dismantle breech mechanism	seconds	$31\frac{3}{5}$
Time to assemble breech mechanism		1m 9s
Distance from seat in chamber at which breechblock will force cartridge home	inches	$5\frac{1}{16}$
Time to fire 1 round, change mainspring, searspring, firing pin, and extractor, and fire another round		3m $33\frac{3}{5}$s.
Time of fire, 100 rounds		4m 41s
Number of rounds fired in 1 minute		20
Number of rounds fired in 3 minutes		65
Number of rounds fired in 5 seconds, first trial		3
Number of rounds fired in 5 seconds, second trial		3
Number of rounds fired in 5 seconds, third trial		2
Time to fire 2 defective and 1 service cartridge	seconds	50
Time to fire 5 rounds after dusting, first test		3m $27\frac{1}{2}$s
Time to fire 5 rounds after dusting, second test		4m 12s
Time required to fire 3 blowbacks and 2 service cartridges		41m 13s
Time required to open breechblock and fire 5 rounds after rusting		6m 25s
Mean velocity	foot-seconds	1,871

	Accuracy.			Accuracy with rapidity.		Alternating two, 500 yards.		Alternating 500 yards and 1,000 yards	
	1,000 yards.	1 mile.	3,000 yards.	1,000 yards.	1 mile.	No. 1.	No. 2.	500 yards.	1,000 yards.
Mean vertical deviation....feet..	1.85	2.44	5.0	1.75	2.77	0.88	0.84	1.1	1.20
Mean horizontal deviation..do...	0.7	1.65	4.04	1.55	1.66	0.68	1.06	1.46	1.44
Mean deviation.....do...	1.97	2.94	6.43	2.34	3.24	1.11	1.36	1.83	1.87
Number of hits	10	10	10	10	10	10	10	10	10
Number of misses	0	0	0	0	0	0	0	0	0
Time to fire				2m $37\frac{1}{5}$s	1m $48\frac{3}{5}$s				
Time to fire both targets						3m 28s		6m	

Firing record and 8 plates are inclosed.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3106)

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*
May 1						
May 2	1					3½
May 2	2					3½
May 2	3					3½
May 2	4	19 20				
May 2	5					
May 2	6					
May 2	7					
May 2	8					
May 2	9					
May 2	10					
May 2	11					
May 2	12					
May 2	13					
May 2	14					
May 2	15					
May 2	16					
May 2	17					
May 2	18					
May 2	19					
May 2	20					
May 2	21					
May 2	22					
May 2	23					
May 2	24					

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test of gun.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
		This gun is 42.3 calibers long from seat of head of cartridge case to muzzle.
		Weight of breechblock and breech mechanism complete, including extractor and handle, 77.5 pounds.
		Starting with the breechblock closed the breech mechanism was removed and dismantled by 1 man (representing the gun) in 25 seconds, using no tools whatever save parts of mechanism. At the first trial 2 parts were forgotten. Upon being allowed a second trial the operation was completed in 31⅘ seconds, nothing forgotten.
		The breech mechanism of this gun consists of 15 parts, including the breechblock itself and the handle by which it is manipulated. The mechanism was assembled, replaced in the gun, and the motion of firing executed, all in 1 minute and 9 seconds.
	Fired to sea at the extreme elevation permitted by the mount.	The time was taken by the proof officer, using a stop watch which reads to one-fifth of a second.
		Lieuts. Harmon, First Artillery, and Peck, Ordnance Department, did all the loading and firing.
		The gun is fired by means of a trigger.
	Fired into sand butt	The breechblock will force the cartridge home when it is 5⅛ inches short of its seat in chamber.
		The recoil produces no blow on the shoulder of the operator.
		The lower left portion of the entrance into the chamber was burred considerably by the point of the shell striking it in loading rapidly. This was caused by the shape of guide which projects from the rear of gun. Burrs removed.
		By closing the breechblock smartly and releasing the lever the instant the breechblock strikes, the reaction will open the block nearly every time.
		The device for clamping the elevation is not convenient.
		A small triangular piece was cut from the upper corner of the rear guide by the representative of the gun and at his suggestion, to facilitate loading.

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*
May 3	25					
May 3	26		1,876 1,872			
May 3	27		1,870 1,869			
May 3	28		1,880 1,880			
May 3	29		1,854 1,859			
May 3	30		1,871 1,881 50+$\frac{1}{16}$			

[For rapidity,

May	31 to 132					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Warming charge	
.....	.....	
.....	.....	
.....	.....	Elevation changes on firing.
.....	.....	
.....	.....	

100 rounds.]

		Recoil for 37 rounds, $4\frac{3}{4}$ inches; recoil for 1 round, 4 inches. Rounds 31 and 32 fired to sea to note the place of striking. After 37 rounds cylinder leaked slightly (tightened). In rapid firing, when the breech-block is opened quickly, the empty case is caught by the rebound of the block and stopped, unless the lever is held down hard by the hand at the completion of the stroke. Time to fire 100 rounds, 4 minutes 41 seconds. Rosin melts on chase after 50 rounds. Soft solder hardened in 17 minutes from end of firing. Rounds 47, 62, and 75, gun missed fire.
.....	.....	In firing for rapidity the ammunition was placed on a table in rear of the gun, and as close to it as possible without interfering with the handling of the gun. Taking the ammunition from this table, 3 men served the gun. The misfires during the firing for rapidity probably were not due to defective cartridges, but were caused by keeping pressure on the trigger while the block was being closed. The sear can be disengaged in this manner, and the blow of the firing pin is then delivered on the wedge, through lugs on the rear of the pin, but it is impossible for the firing pin to strike the primer until the block is completely closed. Lieuts. Harmon and Peck alternated in loading and firing. The changes were made after each group of 25 rounds.

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*	*Right.*	*Inches.*
May 8	133	5 6½			1	
May 8	134	4 56			5½	
May 8	135	4 25½			5½	
May 8	136	4 5½			7	
May 8	137	4 18			4½	
May 8	138	4 20			3½	
May 8	139	4 26½			2	
May 8	140	4 26½			2½	
May 8	141					
May 8	142					
May 8	143					
May 8	144					
May 8	145					
May 8	146					
May 8	147					
May 8	148					
May 8	149					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind from right and rear 45°, 15 miles an hour; barometer, 29.87; thermometer, 71°; humidity, 45.	At discharge muzzle dropped 5 minutes and moved to the right 3.9 points. Struck 250 yards beyond and 50 yards to the left of target. At discharge muzzle moved 4 points right and raised 24 minutes in elevation. Struck 300 yards beyond and on line. Sight set at 2,700 yards. Elevation increased 44 minutes and direction 4.4 points right upon firing. Struck 100 yards beyond. Sight set at 2,600 yards. Elevation increased 35½ minutes and direction 4.5 points right. Struck 46 yards in front and 35 yards right of target. Sight set at 2,650 yards. Direction changed 3.5 points right. Struck 10 feet right and 15 feet beyond target. Sight set at 2,660 yards. Struck 13 yards in front and 9 yards right of target. Sight set at 2,700 yards. Struck 1 foot below and 8 feet left of center of target.	Aimed at the upper left corner. French quadrant used. The drift scale moves slowly to the left, probably due to the muzzle moving to the right on firing.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	3	2	.....	.....	2.6	.....	1.7
1	.....	7	.....	1.4	.....	3.3	.....
.....	3	9	.....	.....	2.6	5.3	.....
.....	1	5	.....	.....	0.6	1.3	.....
5	.....	3	.....	5.4	.....	.....	0.7
4	.....	.....	1	4.4	.....	.....	4.7
8	.....	.....	6	8.4	.....	.....	9.7
5	.....	3	.....	5.4	.....	.....	0.7
.....	7	1	.....	.....	6.6	.....	2.7
.....	13	14	.....	.....	12.6	10.3	.....

Round 140, sight set at 2,700 yards. First to count on target.

Center of impact—	Feet.
Below	0.4
Right	3.7
Mean vertical deviation from center of impact	5
Mean horizontal deviation from center of impact	4.04
Mean deviation from center of impact	6.43

Round 149, shell irregular in flight.

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Date.	No. of fire.	Elevation. (Quadrant.)	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*	*Right.*	*Inches.*
May 9	150	2 05			2	
May 9	151	2 05			1	
May 9	152					
May 9	153					
May 9	154					
May 9	155					
May 9	156					
May 9	157					
May 9	158					
May 9	159					
May 9	160					

[Test gun for

					Left.	
May 11	161				½	
May 11	162					
May 11	163					
May 11	164					
May 11	165					
May 11	166					
May 11	167					
May 11	168					
May 11	169					
May 11	170					
May 11	171					

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weight 756 pounds), at Sandy Hook Proving Ground, May 1 to June 29, 1894—Cont'd.

accuracy at 1 mile.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
.....	Elevation by sight, 1,600 yards. This cartridge failed in rapidity test, but fired this time at first attempt, also the next 2 rounds. Struck 100 yards in rear and 10 feet right of target.	Aimed at the upper left corner.

TARGET.

	Miles per hour.	From center of target.				From center of impact.			
		Vertical.		Horizontal.		Vertical.		Horizontal.	
		Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
From right and front, 30°; barometer, 30.09; thermometer, 80°; humidity, 44.	10	.....	0.5	2	.....	.....	0.95	2.35	.....
	9	.....	2.5	.....	5.5	.....	2.95	.....	5.15
	9	3	.....	1.5	.....	2.55	.....	1.85	.....
	10	.....	0.5	.....	0.5	.....	0.95	.....	0.15
Direct front; barometer 30.09; thermometer, 80°; humidity, 44.	12	.....	1	.....	2	.....	1.45	.....	1.65
	12	2.5	.....	0		2.05	.....	0.35	.....
	12	.....	3	.....	1	.....	3.45	.....	0.65
	12	3	.....	1	.....	2.55	.....	1.35	.....
	12	.....	2	2	.....	.....	2.45	2.35	.....
	12	5.5	.....	.....	1	5.05	.....	.....	0.65

Round 151, the first to count on target.

Center of impact—	Feet
Above	0.45
Left	0.35
Mean vertical deviation from center of impact	2.44
Mean horizontal deviation from center of impact	1.65
Mean deviation from center of impact	2.94

accuracy at 1,000 yards.]

	Miles per hour.	Elevation by sight, 900 yards. Struck target 3 feet below and 5 feet right of center.				Aimed at the top of center of target.			
		From center of target.				From center of impact.			
		Vertical.		Horizontal.		Vertical.		Horizontal.	
		Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
From left and front, 40°; barometer, 30.37; thermometer, 65°; humidity, 54.	12	1.5	.....	.....	1	1.15	.....	.....	1.3
	12	.....	2	0.5	.....	.....	2.35	0.2	.....
	12	.....	2	0.5	.....	.....	2.35	0.2	.....
	9	.....	2	0		.....	2.35	.....	0.3
	9	.....	1.5	2.5	.....	.....	1.85	2.2	.....
	12	3	.....	1	.....	2.65	.....	0.7	.....
	12	4.5	.....	0		4.15	.....	.....	0.3
	7	0		.....	1	.....	0.35	.....	1.3
	7	1	.....	0.5	.....	0.65	.....	0.2	.....
	6	1	.....	0		0.65	.....	.....	0.3

Center of impact—	Feet.
Above	0.35
Right	0.3
Mean vertical deviation from center of impact	1.85
Mean horizontal deviation from center of impact	0.7
Mean deviation from center of impact	1.97

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Record of firing with Maxim-Nordenfelt 6-pounder rapid-fire gun, No. 5761 (Mk. II,

[Test fir

Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure per square inch of bore.	Deflection points.	Recoil
		° ′	*Feet.*	*Pounds.*		*Inc*
June 1	172					
June 1	174 to 238					
June 1	239 to 246					
June 7	247			4, 34,800		
June 7	248			4, 35,100		
June 7	249			4, 38,031		
June 7	250			4, 39,982		
June 7	251			4, 43,956		
June 7	252			4, 47,489		
June 7	253					

[Test with de

June 11	254					
June 11	255					
June 11	256					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	Time to fire 1 round, dismount block, change mainspring, sear spring, firing pin and extractors, mount and fire another round (173), 3 minutes 33½ seconds. The great length of time required for this operation, as compared with the time in which the entire mechanism was dismantled and assembled, was caused by the difficulty of removing the action pin. This pin screws into the block and on previous occasions had easily been removed and replaced by hand; this time a wrench had to be used both to remove and to replace it. The difficulty was caused by the pin mentioned being slightly bent. It was not straightened.	In firings of June 1 the arrangement of the ammunition and the number of men serving the piece were the same as in the 100-round test for rapidity. In the 3-minute test Lieuts. Harmon and Peck alternated in loading and firing, changing at the end of each 1.5 minutes.
	Rounds fired in 1 minute, 20; rounds fired in 3 minutes, 65; 1 missfire counted as a round fired. The number of rounds fired in 1 minute was determined by noting the number fired in the first minute of the 3-minute test.	
	Rounds fired in 5 seconds, first trial, 3; rounds fired in 5 seconds, second trial, 3; rounds fired in 5 seconds, third trial, 2.	
	Service charge	
	1 ounce rifle powder added to charge	
	2 ounces rifle powder added to charge	
	2½ ounces rifle powder added to charge	
	3 ounces rifle powder added to charge. Slight blowback.	
	3½ ounces rifle powder added to charge. Firing pin fouled by residue so that a monkey wrench had to be used to remove it from the block. Cap from primer blown back into hole for firing pin, wedging it. The mainspring was found slightly set.	
	The breech mechanism was cleaned, oiled, replaced, and round 253 fired.	

ive cartridges.]

	The cartridge case was prepared by filing obliquely through the edge of the rim so as to just show an opening to the interior at the junction of the head and wall. The slots are at the extremities of two diameters, at right angles with each other. Cartridge placed in the gun so that the solid part of the rim came opposite the extractors. There was quite an escape of gas, as a matter of course, but the block opened easily.	
	The cartridge case was prepared by sawing slots through the head so as just to show an opening to the interior. The slots were at right angles with each other, and each was half way between the primer and the rim. Block opened without difficulty.	
	Service cartridge. Fired at first attempt, showing all parts in working condition. Time to fire 2 defectives and 1 service round, 50 seconds. The gun was taken to the blacksmith shop to be dusted without any part being cleaned in any degree. Care was exercised to avoid removing residue from the breech mechanism in handling the gun.	

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*
June 11	257					
June 11	258					
June 11	259					
June 11	260					
June 11	261					
		[For accuracy with rapidity at two 500-yard targets				
June 12	262					
June 12	263					
June 12	264					
June 12	265					
June 12	267					
June 12	269					
June 12	271					
June 12	273					
June 12	275					
June 12	277					
June 12	279					
June 12	281					
June 12	283					
June 12	266					
June 12	268					
June 12	270					
June 12	272					
June 12	274					
June 12	276					
June 12	278					
June 12	280					
June 12	282					
June 12	284					

Digitized by Google

test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	Breechblock opened without difficulty, but it was necessary to use some water before it would work easily, and it required two or three snappings due to the dust around firing pin.	The attached blue prints show the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. The gun was cocked. The dust used was burnt sand from the proof butts. The passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry, and answered well for this purpose. The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable. After being dusted, the gun was remounted, and the time to open the block and fire the 5 rounds was noted. Time, 3 minutes 27½ seconds.
	Some water was thrown over block at this round.	
	The gun was not sponged before this firing, there being little or no dust in the bore.	

placed 80 feet apart, alternating on the two targets.]

Wind right and rear, 45°, 8 miles an hour; barometer, 30.12; thermometer, 79°; humidity, 71.

Fired at No. 1 target. Elevation by sight, 600 yards. Struck target 3 feet below and 1 foot right of center.
Fired at No. 2 target. Elevation by sight, 610 yards. Struck target 2 feet 3 inches below and 1 foot 6 inches right of center.
Fired at No. 1 target. Elevation by sight 630 yards. Struck target 1½ feet above and 2 feet 8 inches right of center.

Aimed at bull's-eye.
Sight had to be adjusted after the eighth round.

TARGET No. 1.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
0.667		4.25			1.0248	1.4667	
	0.5	2			2.1918		0.7833
1.25		3.25			0.4418	0.4667	
2.25		3.25		0.5582		0.4667	
3.167		3.583		1.4752		0.7997	
2.417		3		0.7252		0.2167	
1.5		2.667			0.1918		0.1163
1.167		2			0.5248		0.7833
1.667		2			0.0248		0.7833
3.333		1.833		1.6415			0.9503

Center of impact— Feet.
Above 1.6918
Right 2.7833
Mean vertical deviation from center of impact 0.88
Mean horizontal deviation from center of impact 0.68
Mean deviation from center of impact 1.1141

TARGET No. 2.

0.5		0.583			1.7749		1.4002
1.083		1			1.1919		0.9832
2		1.167			0.2749		0.8162
3		0.5		0.7251			1.4832
2.583		1.5		0.3081			0.4832
1.75		1.833			0.5249		0.1502
1.833		3.333			0.4419	1.3498	
2.5		3.833		0.2251		1.8498	
3.667		2.583		1.3921		0.5998	
3.833		3.5		1.5581		1.5168	

Center of impact— Feet.
Above 2.2749
Right 1.9832
Mean vertical deviation from center of impact 0.8417
Mean horizontal deviation from center of impact 1.0632
Mean deviation from center of impact 1.3561
Time to fire the 20 rounds, 3 minutes and 28 seconds.

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*		*Inches.*
June 12	285					
June 12	286					
June 12	287					
June 12	288					
June 12	289					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	Blowback	
	Six misfires. A service cartridge was tried and it also missed. Upon dismounting the breech mechanism the firing pin was found fouled by residue and slightly upset; a new one was substituted. The second blowback was fired at the first attempt with the new pin.	
	Blowback. Two attempts failed to explode the primer. The cartridge was removed and a bucket of water was thrown over the block to soften the residue around the pin. Replacing the cartridge, 3 more misfires occurred. A service cartridge was substituted and it also missed fire. The breech mechanism was dismantled and the new pin found fouled by residue and upset just as the old one had been by the preceding round. Another new firing pin was substituted. The blowback cartridge was then tried again, the result being 3 misfires. A service cartridge was substituted, and fired at the first attempt.	
	The blowback was again tried and again failed. The primer was well indented. It had evidently been rendered defective in thinning. A new blowback was ordered prepared and when ready was fired at the first attempt.	The primers were thinned in this instance by putting the empty cases in the lathe and turning them down.
	A service cartridge tried next resulted in 3 misfires. The block was dismantled, the parts washed, reassembled, and the service cartridge tried again; it again failed and the block was opened with considerable difficulty. The mechanism was again dismantled and the parts thoroughly cleaned. The force of the powder gas against the firing pin was sufficient to drive the mainspring back against the block, burring the spring and indenting the block. The burr was removed from the spring by a couple of rubs with a file. The mechanism was assembled and a service cartridge fired at the first attempt. The block again stuck, owing, probably, to the absence of lubricant; it was opened quite readily after emptying a pail of water over it. A small spring in the trigger found broken was not replaced, not being necessary. Time to fire the 3 blowbacks and 2 service cartridges, 41 minutes and 13 seconds.	

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Date.	No. of fire.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	Recoil.
		° ′	*Feet.*	*Pounds.*	*Left.*	*Inches.*
June 13	290				0	
June 13	291				0	
June 13	292				1	
June 13	293					
June 13	294					
June 13	295					
June 13	296					
June 13	297					
June 13	298					
June 13	299					
June 13	300					
June 13	301					
June 13	302					

[Rapidity with

					Right.	
June 13	303				3	
June 13	304					
June 13	305					
June 13	306					
June 13	307					
June 13	308					
June 13	309					
June 13	310					
June 13	311					
June 13	312					
June 13	313					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind from front and left, 85°, 7 miles an hour; barometer, 30.22; thermometer, 63°; humidity, 79.	Sight set at 1,700 yards. Struck 175 yards beyond. Sight set at 1,600 yards. One misfire. Struck 22 yards in front and 20 feet to the right of the right edge. Sight set at 1,650 yards. One misfire. Struck target 4½ feet below and 2½ feet right of center.	Aimed at bull's-eye. A new mainspring put in after round 292.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	3.5	1	.....	.....	2.748	.....	2.567
.....	2.5	2.5	.....	.....	1.748	.....	1.067
.....	1.5	2	.....	.....	0.748	.....	1.567
4	.....	1	.....	4.752	.....	.....	2.567
.....	4.66	4	.....	.....	3.908	0.433	.....
4.75	.....	3	.....	5.502	.....	.....	0.567
0.33	.....	4	.....	1.082	.....	0.433	.....
1.83	.....	4.17	.....	2.582	.....	0.603	.....
.....	2.17	6	.....	.....	1.418	2.433	.....
.....	4.1	8	.....	.....	3.348	4.433	.....

Center of impact—	Feet.
Below	0.752
Right	3.567
Mean vertical deviation from center of impact	2.7748
Mean horizontal deviation from center of impact	1.667
Mean deviation from center of impact	3.2446

Time to fire the 10 rounds, 1 minute 48⅘ seconds.

accuracy at 1,000 yards.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Wind front and left, 85°, 8 miles an hour; barometer 30.25; thermometer, 63°; humidity, 68.	Sight set at 950 yards. Struck target 1 foot above and 2 feet right of center.	Aimed at the upper left corner. Smoke interfered.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
2.5	.....	0.5	.....	1.85	.....	0.15	.....
1.5	.....	0.5	.....	0.85	.....	0.15	.....
0		1.5	.....	.....	0.65	1.15	.....
0		3	.....	.....	0.65	2.65	.....
.....	2	4	.....	.....	2.65	3.65	.....
2	.....	.....	1	1.35	.....	.....	1.35
4.5	.....	0		3.85	.....	.....	0.35
1.5	.....	.....	1	0.85	.....	.....	1.35
.....	1	.....	1	.....	1.65	.....	1.35
.....	2.5	.....	3	.....	3.15	.....	3.35

Center of impact—	Feet.
Above	0.65
Right	0.35
Mean vertical deviation from center of impact	1.75
Mean horizontal deviation from center of impact	1.55
Mean deviation from center of impact	2.3377

Time to fire the 10 rounds, 2 minutes 37½ seconds.

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Record of firing with Maxim-Nordenfelt 6-pounder rapid-fire gun, No. 5761 (Mk. II. 1[illegible]

[Rapidity with accuracy at 500 and 1000 yard

Date.	No. of fire.	Elevation	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Deflection points.	R[illegible]
		° ′	*Feet.*	*Pounds.*	*Right.*	*Inches*
June 15	314				3	
June 15	315				0	
June 15	316				3	
June 15	317				0	
June 15	318					
June 15	320					
June 15	322					
June 15	324					
June 15	326					
June 15	328					
June 15	330					
June 15	332					
June 15	334					
June 15	336					
June 15	319					
June 15	321					
June 15	323					
June 15	325					
June 15	327					
June 15	329					
June 15	331					
June 15	333					
June 15	335					
June 15	337					

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Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	Gene
Wind right and rear, 45°, 10 miles an hour; barometer, 30.22; thermometer, 68°; humidity, 43.	Fired at 1,000-yard target. Sight set at 950 yards. Struck target 5 feet 3 inches below, and 1 foot 10 inches right of center. Fired at 500-yard target. Sight set at 600 yards. Struck target 1 foot 3½ inches above, 3 feet 4 inches right of center. Fired at 1,000-yard target. Sight set at 960 yards. Struck target 6 inches above, and 2 feet 3 inches right of center. Fired at 500-yard target. Sight set at 600 yards. Struck target 3 feet below, and 7 inches left of center.	

TARGET 1,000 YARDS.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
.....	0.5	2.25	.....	.....	2.0584	.....	1.3417
.....	1	5	.....	.....	2.5584	1.4083	.....
1	.....	6	.....	.....	0.5584	2.4083	.....
0.75	.....	2.5	.....	.....	0.8084	.....	1.0917
2.5	.....	5	.....	0.9416	.....	1.4083	.....
4	.....	4.5	.....	2.4416	.....	0.9083	.....
1.167	.....	1.833	.....	0.1086	.....	.....	1.7587
2.667	.....	2	.....	0.6086	.....	.....	1.5917
2.5	.....	2.167	.....	0.9416	.....	.....	1.4247
2.5	.....	4.667	.....	0.9416	.....	1.0753	.....

TARGET 500 YARDS.

.....	5	3.917	.....	.....	2.4583	2.592	.....
.....	2.667	2	.....	.....	0.1253	0.675	.....
.....	3	0.25	.....	.....	0.4583	.....	1.075
.....	2	1	.....	0.5417	.....	.....	0.325
.....	2.167	2	.....	0.3747	.....	0.675	.....
.....	2.333	.....	0.917	0.2087	.....	.....	2.242
.....	2.25	.....	1.167	0.2917	.....	.....	2.492
.....	5	3.667	.....	.....	2.4583	2.342	.....
.....	0.667	2.333	.....	1.8747	.....	1.008	.....
.....	0.333	0.167	.....	2.2087	.....	.....	1.158

Aimed at the
Center of im
Above..
Right...
Mean verti
from cente
Mean horizo
from cente
Mean deviat
ter of imps

Aimed at bul
Center of im
Below ..
Right...
Mean verti
from cente
Mean horizo
from cente
Mean deviati
of impact .
Time to fire
utes.

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Record of firing with Maxim-Nordenfelt 6-pounder rapid-fire gun, No. 5761 (Mk. II, 1

[Second

Date.	No. of fire.	Elevation.	Instrumental velocity. 125 feet from muzzle.	Pressure. per square inch of bore.	Deflection points.	Re
		° ′	*Feet.*	*Pounds.*		Inche
June 21	338 to 342					

[Rust test

June 27						
June 29	343 to 347					

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eight 756 pounds), at Sandy Hook Proving Ground, May 1 to June 29, 1894—Cont'd.

lust test.]

Wind, strength and direction.	Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	A cartridge was inserted, but the block could not be closed. After a few trials the cartridge was withdrawn and the dust removed from the seats for the extractors, and the cartridge again inserted. It and the following 4 rounds were then fired without difficulty. No oil or water having been used throughout. Time to open block and fire 5 rounds, 4 minutes 12 seconds.	Owing to the lack of uniformity in the conditions of the different breech mechanisms when subjected to the first dust test, it was considered advisable to repeat this test. In the second dust test all the parts of the different mechanisms were thoroughly washed with hot water and soap; they were then carefully dried and lightly oiled. When subjected to the blast of dust the gun was not cocked. The arrangement for dusting and the material used were the same as in the first dust test. The gun was subjected to a blast of dust for 8 minutes. The block was opened without any difficulty. It was half closed and opened several times rapidly to jar the dust out of the mechanism. A bunch of dry waste was forced through the bore twice to remove the dust from the gun.

gun not cocked.]

		The breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap. The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical, and was lowered into the solution just enough to cover the breech mechanism. Before immersing, a soft wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven into the rear end of the barrel to prevent unnecessary rusting of the chamber. The handle was left on because it can not be removed without dismounting the mechanism, and in this case it did not interfere with dipping the gun. Gun immersed at 9:31 o'clock, and taken out at 9:56 o'clock, having remained 25 minutes.
		In opening the block, the mechanism was oiled, using an oil can and dropper. One man kept a strain on the handle, while another used a brass drift and hammer on the block. The mechanism was not dismantled till the firing was completed. The main shaft and its journal were found burred. The burrs were removed by Mr. Huber, representing the gun. Firing conducted in the presence of the Ordnance Board. Present: Maj. F. H. Phipps, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

	Hours.	Minutes.	Seconds.
Started to open block at	10	2	0
Block opened at	10	7	0
Time to open block		5	0
Time to open block and fire 5 rounds		6	25

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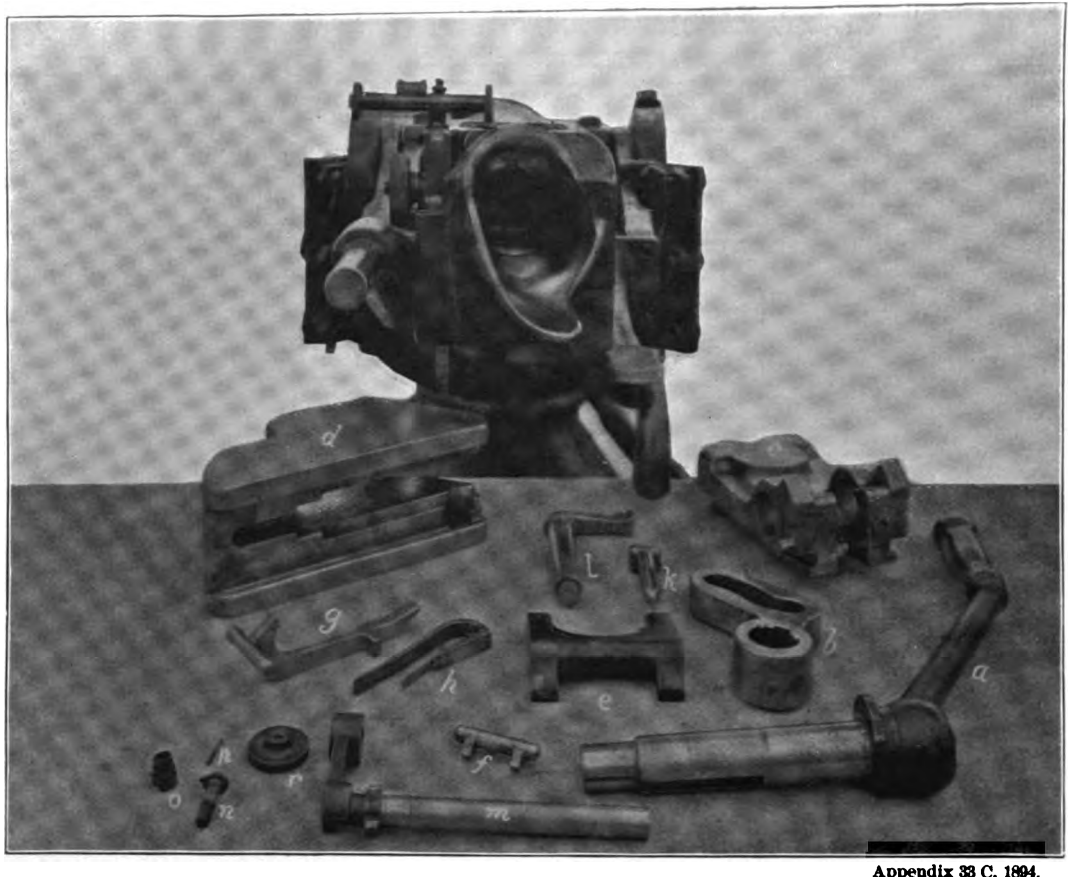

Appendix 33 C. 1894.

MAXIM-NORDENFELT 6 PDR. R. F. GUN.

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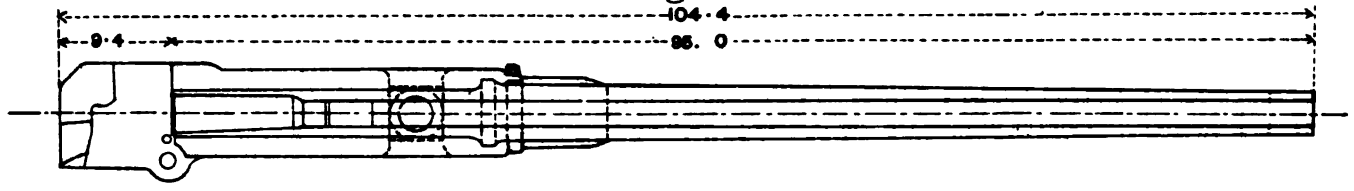
Fig. 1

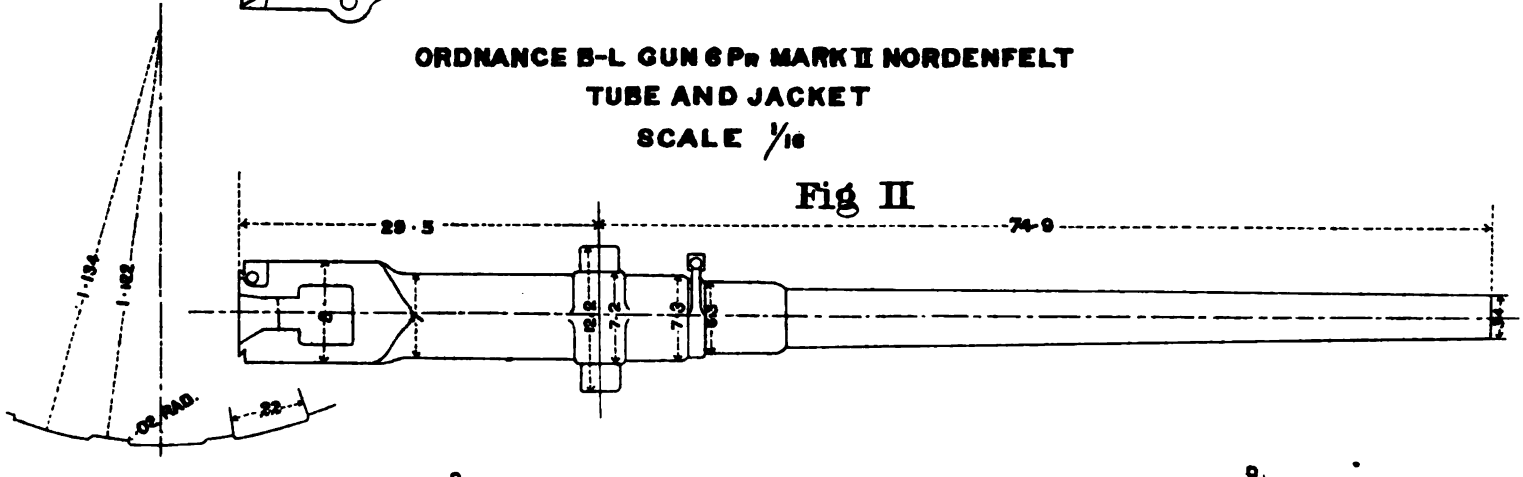


ORDNANCE B-L GUN 6 Pr MARK II NORDENFELT

TUBE AND JACKET

SCALE 1/16

Fig II



NUMBER OF LANDS	24
EXACT CALIBRE	2·244
DEPTH OF GROOVES	·012
WIDTH	·22
INITIAL TWIST OF RIFLING	1°
FINAL	6°

1 TURN IN 30 CALIBRES

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PLATE III.

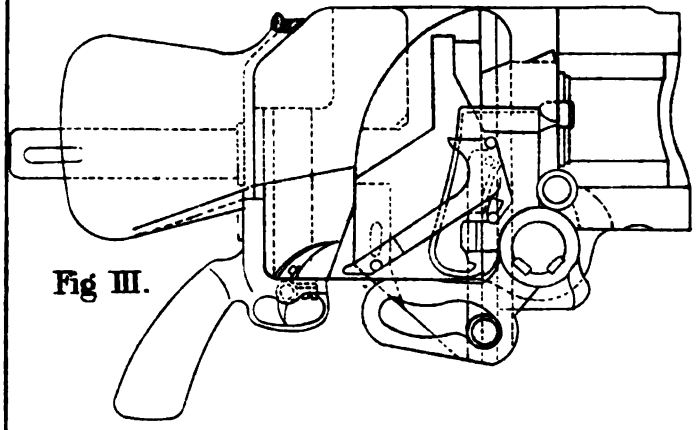
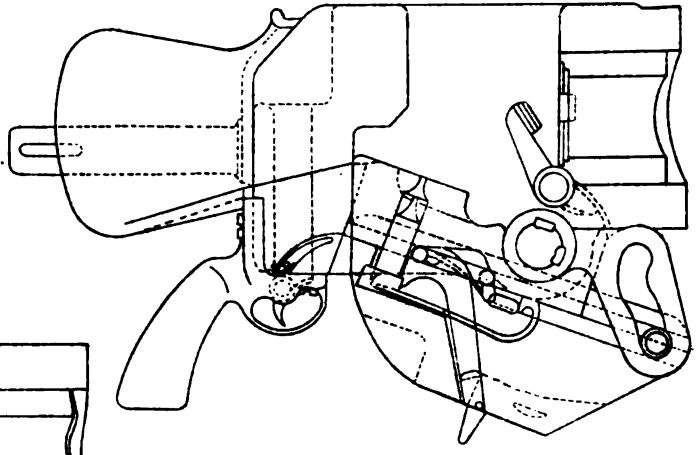


Fig III.

Fig IV.



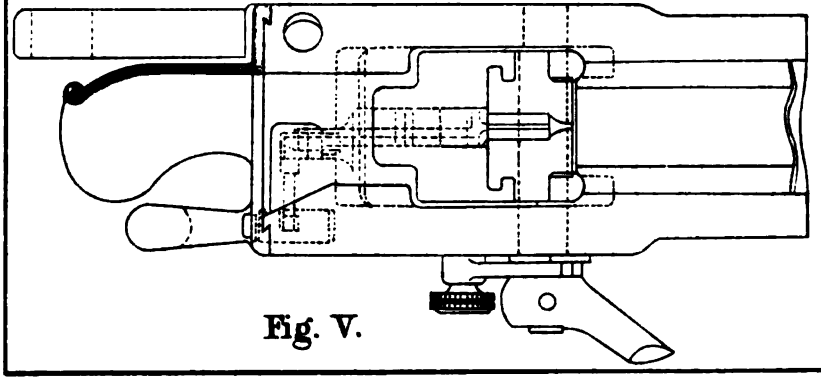


Fig. V.

ORDNANCE B.-L. GUN. (MARK II.)

NORDENFELT

MECHANISM.

SCALE ½.

Appendix 33 C, 1894.

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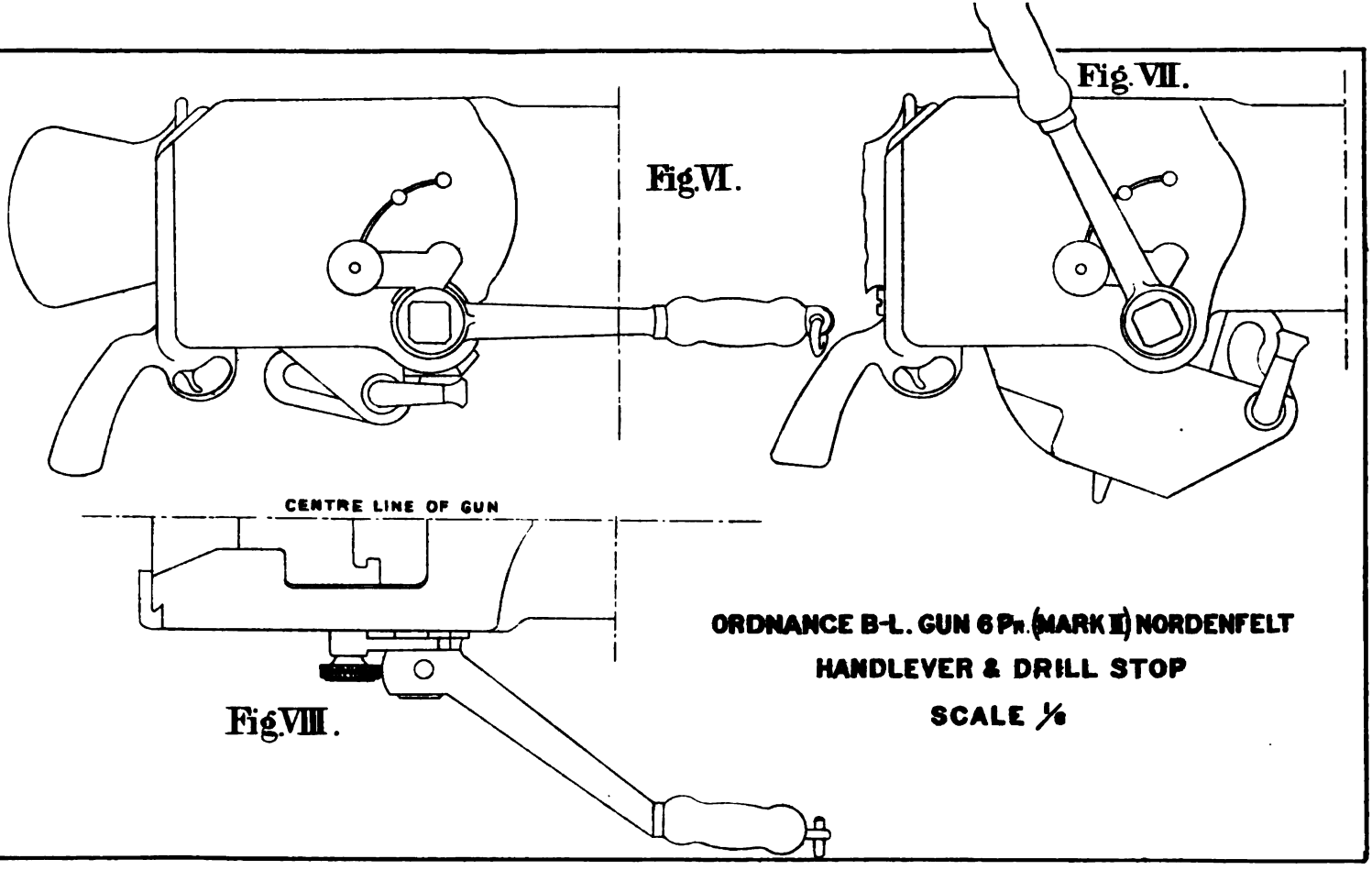

ORDNANCE B-L. GUN 6 Pr. (MARK II) NORDENFELT

HANDLEVER & DRILL STOP

SCALE ⅛

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PLATE V.

FORE SIGHT.

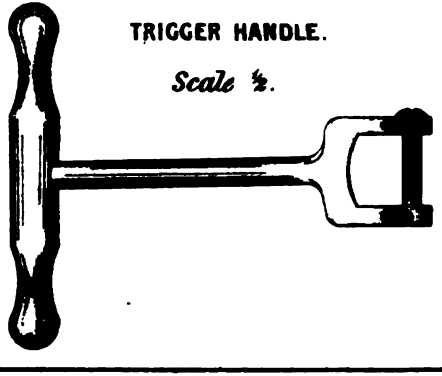
Scale ½.

FRONT VIEW.

SIDE VIEW.

TRIGGER HANDLE.

Scale ½.

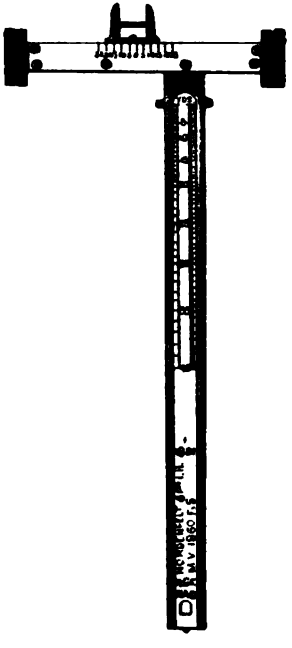


HIND SIGHT.

Scale ¼.

FRONT VIEW.

REAR VIEW.



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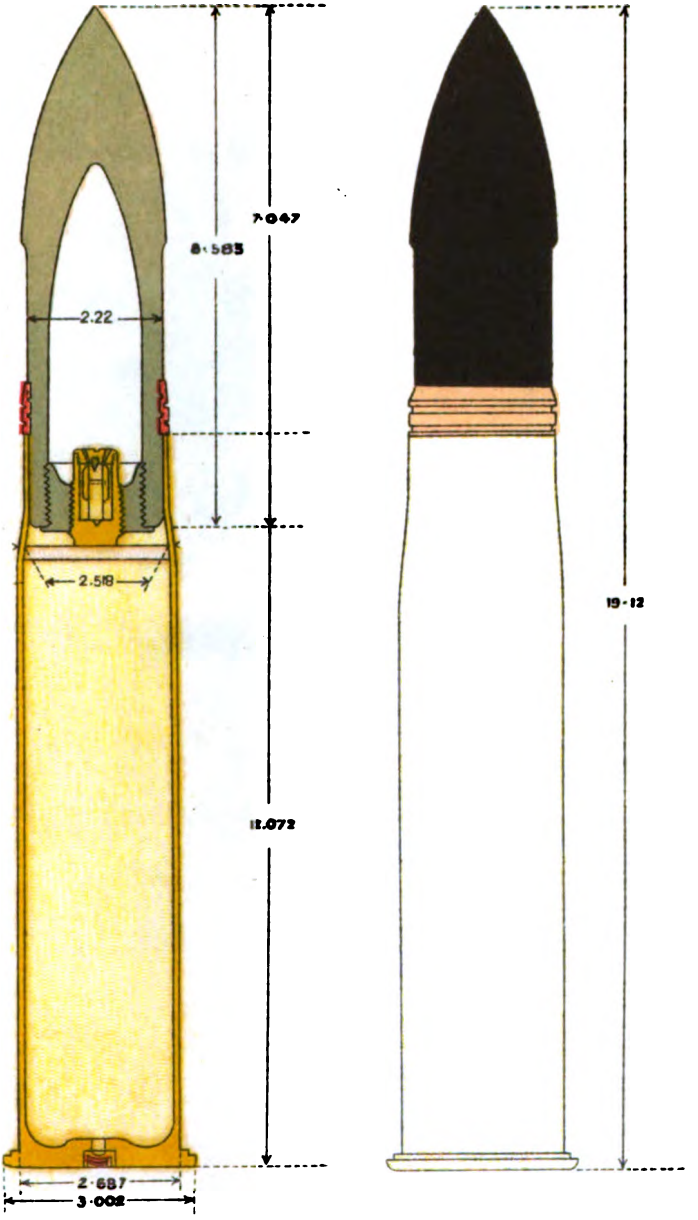
CARTRIDGE QUICK FIRING 6 Pr SHELL MARK I & II.

WITH STEEL SHELL FUZED.

SCALE ½.

P.C. 1 lb. 15 ozs.



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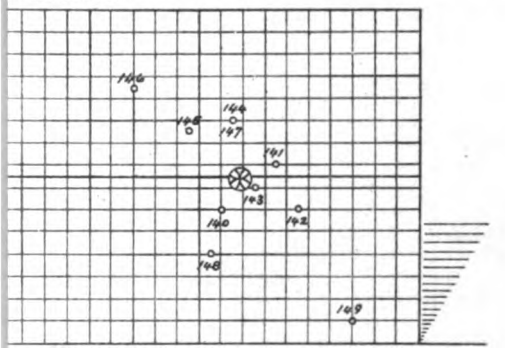
TARGET 3000 YARDS FROM GUN. MAY 8TH 1894.

ACT. HITS. 10.



TARGET, 30'x40'.

ROUND NO.	MILES PER HOUR.	DIRECTION.		
140	15	Right Front 45°		
141	"	"	"	"
142	"	"	"	"
143	"	"	"	"
144	"	"	"	"
145	"	"	"	"
146	"	"	"	"
147	"	"	"	"
148	"	"	"	"
149	"	"	"	"

5'.0

4'.04

6'.43

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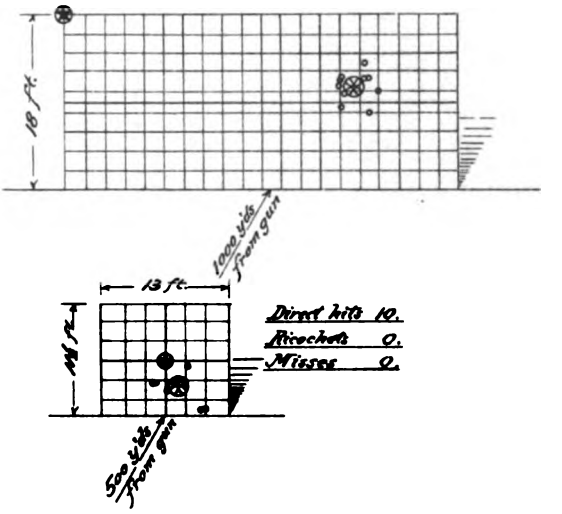
Alternating shot by shot on targets

June 15/94. Rounds 218 to 237 inc.

Direct hits 10. Ricochet 0. Misses 0.



1.10 ft. 1.20 ft.

1.46 ft. 1.44 ft.

1.83 ft. 1.87 ft.

20 rounds = 6m. 0 sec.

10 miles per hour, right and rear 45°

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APPENDIX 33 D.

TEST OF 6-POUNDER SEABURY RAPID-FIRE G

(8 plates.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENA
GOVERNORS ISLAND, NEW YORK H.
New York City, Octob

SIR: The following report of the test of a Seabury 6-p
fire gun is respectfully submitted:

DESCRIPTION.

Fig. 1, Pl. I, is a rear view, showing the breech with th
closed. Fig. 2 represents a top view, corresponding with
represents a transverse vertical section in the horizont
fig. 2. Fig. 4, Pl. II, represents a central horizontal s
sponding with figs. 1, 2, and 3. Fig. 5, pl. 2, is a side view, c
with figs. 1, 2, 3, and 4. Fig. 6 represents a central ve
corresponding with figs. 1, 2, 3, 4, and 5, except that in t
firing pin is represented as cocked and in the previous
figures it is represented in the position it occupies after fi
is a back view of the sear. Fig. 7, Pl. III, represents a
zontal section of the breech and a top view of the breech
operating mechanism, showing the breechblock as turne
to its withdrawal from the breech. Fig. 8 is a plan view,
tion, representing the breechblock as drawn back with
ready to be swung back with the carrier. Fig. 9, Pl. IV,
ilar to fig. 1, except that the breech is represented open
horizontal sectional view, corresponding with fig. 9. Fig.
diagram, which will be hereafter explained.

Similar letters and numerals of reference designate
parts in all the figures.

A is the breech of the gun, B is the breechblock, and C
block carrier, hinged on a pin D to one side of the breech.
ple represented the lug of the member E^1 of the hinge, w
to the breech, is constructed on a metal band E, which i
firmly secured upon the breech A as to be practically
This construction of the fixed portion E^1 of the hinge on
a matter of convenience for adapting the invention to
made. It is obvious that the fixed portion of the lug E
may be constructed directly upon the breech of the gun.
block D is of the well-known kind, having upon its exte
screw threads corresponding with mutilated screw thread
of the gun.

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The carrier C consists of a strong ring, having upon one side of it hinge lugs C^1 C^1, through which and the fixed lug E^1 on the breech the pin D passes. The external circumference of the ring of the said carrier is fitted to a cavity *a* in the breech, the said cavity being in the example represented in the fixed band E, which, as hereinbefore mentioned, is substantially a part of the breech. The fit of the said ring to the breech is represented as slightly tapering, to insure closeness and facilitate opening. The opening of the carrier C, in which the breechblock is received, consists, as shown in fig. 3, of three concentric arc-formed bearings *c* and three intermediate arcs c^1 of larger radius and concentric with *c*, the circle of the bearings *c* fitting the mutilated cylindrical portion of the breechblock between and behind the screw threads and the spaces within the arcs c^1 corresponding with the mutilated portions of the interior of the breech to permit the breechblock to slide back through the closed carrier during the act of withdrawing the block from the breech. The breechblock has a portion *d* of its circumference in rear of its screw threads of plain cylindrical form, as shown in figs. 7 and 8, so that it may turn freely in the bearings *c* in the carrier, and on the rear end of the block there is secured by screws *e e* a plate B^1 the edges of which project around the block in the form of a flange, the said plate and flange being practically a part of the breechblock. The said plate B^1 serves also the purpose of carrying a rearward projecting yoke B^2, through which passes the hand lever F, which serves the purposes of turning the breechblock, giving the said block the requisite longitudinal movement and moving the carrier on its hinge, and may also serve the purpose, as in the present example, of cocking the firing pin and operating the cartridge-shell extractor. The said lever F has its fulcrum upon a pin *g* between the lugs C^1 C^1 of the carrier C, upon which pin it is capable of moving toward and from the breech of the gun, the said lugs C^1 C^1 being extended in a rearward direction beyond the pin D, as shown at C^2 C^2 in figs. 2, 4, and 5, for the purpose of carrying the said fulcrum pin *g*. The pins D and *g* are secured in place by a button 12. The slot *h* provided in the yoke B^2 for the lever F to work in is of such form that the lever in moving backward within said slot from the position shown in figs. 1 and 2, in which the breech is closed, will turn the breechblock far enough to bring the screw threads thereon opposite to the mutilations of the screw threads in the breech and to the recesses or spaces c^1 c^1 between the bearings *c c* in the carrier, and thereby permit the breechblock to move backward. The form which is given this curved slot is shown in the diagram (fig. 11), which shows the outlines of the yoke, and its slot and a transverse section of the lever, the full outlines showing the relative positions of the slot and the lever when the breechblock is screwed up, and the dotted outlines showing the relative positions of the slot and the lever when the breechblock is unscrewed. It will be seen that the forward or lower portion of the curve is in line substantially parallel with the bore of the gun and with the plane of movement of the lever, and that the curvature is thence developed somewhat in the form of a screw thread with a gradually diminishing pitch, so that the lever will operate most effectively to turn the breechblock in commencing to unscrew it and in completing the screwing it up. Moreover, when in firing the gun there is a tendency to turn the breechblock this tendency to turn is resisted normally by the lever, which serves as an abutment to the portion 13 of the slot. In this resistance the lever is sustained in part by the long support which is provided for it on the fulcrum pin *g* and in part by engaging with the breech in a notch *y*, provided in the latter

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o receive it, and during the movement of the lever in the slot *h* the aid lever is supported vertically in part by the fulcrum pin and in part n the opposite side of the carrier to the fulcrum pin by two horizontal guides g^1 g^2, provided one above and the other below it on the carrier), which is then supported in the cavity *a* in the breech. The longi- udinal movement of the breechblock within the carrier to withdraw it rom the breech, as shown in fig. 8, after it has been unscrewed and the ubsequent swinging aside of the carrier and block to open the breech, s shown in fig. 10, are affected by the direct action of the lever against he rear portion 14 of the slot *h*. The breechblock is, during its longi- udinal movement, guided rectilinearly in part by a guide H, which projects from the rear of the carrier through an opening in the lever, nd in part by a pin *l* (*see* figs. 3 and 10), which is screwed into the car- ier from the outside thereof and the point of which projects within the arrier and enters a straight groove *m* (*see* figs. 7, 8, and 10) in the block. This pin *l* also prevents the breechblock from turning during its back- ward and forward movements, and acts as a stop against the front end of said groove to limit the backward movement of the block within the arrier, and also serves, by the engagement of said end of the slot gainst it, to make an operative connection between the carrier and the ever for swinging the carrier backward on its hinge. The said groove *n* is prolonged at its rear end in the form of a female screw thread m^1, o that although the pin *l* is always in it the said pin does not prevent he turning of the block in the screw threads of the breech. The guide H is represented as secured to the carrier by a screw *k*.

In order to provide for unlocking the carrier from the breech there s provided an opening from the notch i^1 directly through the side of he breech, as shown at 15 in fig. 3, and in this opening is placed a pin ^{5}, which projects outward in such manner that pressure may be applied o it by the thumb or finger to press in the latch bolt clear of the breech. This pin has its inner end so enlarged that it can neither be pulled out of the breech nor pressed into the hole provided for the latch bolt *i* in he carrier.

I is the firing pin passing centrally through the breechblock and working in a guide at *n* in the front part of the block itself and a guide i^1 in the plate B^1. The mainspring J, which is coiled around the firing in and contained within a central cavity in the breechblock, abuts gainst the plate B^1 and presses against a collar or shoulder *o* on the in. The pin is prolonged backward and passes through a slot in the ever F and is provided with a crosshead *p*, with which the said lever ngages for the purpose of drawing it back to the cocked position.

J^* (*see* particularly figs. 6 and 6^*) is the sear, consisting of a plate which slides against the back of the breechblock and in which there re two openings p^* *q*, through one of which the firing pin passes, and which is large enough for the larger portions of the firing pin to pass hrough it, and the other of which receives the sear spring *r*. The upper dge of the opening, which constitutes the tooth for engaging in the ocking notch o^1 of the firing pin, is beveled, as shown at p^1 in figs. 6 nd 6^*, so that the shoulder o^2 on the pin may pass by it in the act of ocking. The sear is guided by a box J^1, which is secured by dove- ailed edges and a screw r^1 to the plate B^1 or breech. In this box is a quare projection s^1, which passes through the opening *q* of the sear nd which constitutes a bearing for the sear spring *r*, which pushes ownward against the lower part of the said opening. The screw r^1 asses through this projection s^1.

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K, figs. 5 and 6, is the trigger, fitted to a stock K^1, which is inserted and secured in a dovetailed grove *t* (*see* figs. 1 and 3) in the bottom the breech of the gun. This trigger liberates the firing pin by pushing upward against the sear, but is only in contact therewith when the breech is closed.

L, figs. 4, 7, 9, and 10, is the cartridge-shell extractor, consisting of a slide which works back and forth in a guide *u* in one side of the cavity which receives the breechblock.

ACTION OF THE MECHANISM.

Supposing the gun to have been fired and the parts left in the positions and conditions represented in figs. 1, 2, 3, and 4, all that has to be done for performing the several operations is to pull back the lever from the position in which it is shown in the figures above mentioned and return it. During the first part of the backward movement of the said lever it moves in the slot *h* of the yoke B^3 and unscrews the breechblock, as shown in fig. 7, and at the same time it draws back the firing pin into position to be caught by the sear, the unscrewing of the block at the same time starting the cartridge shell. The continued movement of the lever in contact with the back of the slot *h* withdraws the breech block from the gun, as shown in fig. 8, and just before this withdrawal is completed the wedge-like portion j^1 of the breechblock acts upon the lever i^2, and thereby draws in the latch bolt *i* and unlocks the carrier C, and as the withdrawal is completed the front end of the slot *m* comes against the pin *l* and the projection i^3 drops into the notch j^3, and the carrier is thus compelled to move with the breechblock during the further continued movement of the lever, by which the breechblock and carrier are together swung aside on the pin D, as shown in figs. 9 and 10. The still further continued movement of the lever and the carrier brings the part v^2 of the carrier against the extractor lever M and pulls back the extractor and with it the empty cartridge shell. The said movement of the lever is, however, not intermitted between the several operations above described, but is continuous. The cartridge shell having been removed and a new charge having been inserted in the chamber of the gun, the lever is returned to the positions shown in figs. 1, 2, 3, and 4. During the first part of this return movement the spring *w* returns the extractor, and as by the continued movement of the lever the carrier passes into the cavity *a* of the breech the bevelled end of the latch bolt *i*, running into the said cavity, causes the latch bolt to be pressed inward and at the same time causes the projection of the lever i^2 to be thrown out of the recess j^3 to liberate the breech block, which then commences to move forward, while the latch bolt is sprung into the notch i^1 in the breech to lock the carrier. By the continued forward movement of the lever the block must be pushed forward, as the block is prevented from turning by the pin *l* until when the part m^1 of the groove *m* m^1 in the block arrives at the pin; the lever by its action in the yoke screws up the block. All is now ready for firing.

It will be understood by reference to fig. 4 that the firing could not take place until the lever F has entered the notch *x* in the breech and the block has been securely locked, as, if the firing pin should accidentally let off while the lever is not locked, the crosshead of the pin would strike the lever and the pin would be arrested with its point short of the cartridge or priming.

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2. Carrier.
3. Operating lever.
4. Extractor.
5. Extractor lever.
6. Mainspring.
7. Firing pin.
8. Sear.
9. Sear spring.
10. Housing for 8 and 9.
11. Hinge pin for 2.
12. Fulcrum pin for 3.
13. Fulcrum pin for 4.
14. Rotating piece.
16. Sear lock.
17. Spring to operate 16.
18. Screw to secure 17 to
19. Screw to join 10 to 14
20. Locking bolt.
21. Spring to operate 20.
22. Screw to secure 21 in
23. Cocking piece.
24. Securing pin to retain
25. Guide for 1.
26. Screw to secure 25 to
27. Guide for 3.
28. Screw to secure 27 to

The following programme was adopted for the test:

The gun to be carefully examined by the board. The nu of the breech mechanism, their strength, simplicity, and action to be noted; also the ease, safety, and certainty o mechanism as a whole. Note especially the action of the f extractor and the maximum outward position of the cartı can be pushed home by the breechblock. During this ex rounds to be fired at will.

VELOCITY.

Five rounds to be fired for velocity with full charges.

ACCURACY.

Ten rounds to be fired at each range of 1,000 yards, 1 m yards, the same conditions of aiming being repeated at ea the mean deviations determined.

RAPIDITY.

Determine number of rounds that can be fired in 5 seco also number of rounds that can be fired in 1 minute, 3 mi minutes, respectively, and finally the time required to fir noting carefully during the firing, and especially at en rounds, the condition of the gun as regards heat and ease of action.

Two detachments of men alternating every 25 or 50 roun thought advisable.

RAPIDITY WITH ACCURACY.

Fire 10 aimed shots as rapidly as possible at the 1,00 mile targets; also 10 aimed shots at targets in same lin of 500 and 1,000 yards alternately; also 10 aimed shots a targets at about 500 yards range, placed about 75 feet ap

DUST.

The mechanism to be exposed to a blast of fine dust ner as to insure its being uniformly and equally covered after which 20 rounds to be fired as rapidly as possible.

EXCESSIVE CHARGES.

The gun to be fired with 5 charges giving gradual pressures up to 45,000 pounds per square inch, if such attainable.

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The gun to be tested with defective cartridges in the same manner as is usual in the trial of small arms.

Any rounds that may remain after the above tests to be expended in such manner as may be deemed best by the board as a result of the circumstances developed; the last five rounds to be fired after the mechanism of the gun has been rusted in a thorough and uniform manner.

The test was commenced in accordance with the programme on July 6 last. There was no expert representative of the gun present at any time. The manipulation of the mechanism before firing was easy and rapid. There seems to be no tendency of the block to fly open upon firing, and it is impossible to fire the piece before the block is closed; it is also impossible to cause a missfire by pulling the lanyard and disengaging the sear before the block is closed and locked.

The position of the sight in the hinge of the breechblock is unsatisfactory and should be changed.

The length of the gun is 46.1 calibers from the seat of the head of the cartridge case to the muzzle; the weight of the breech mechanism complete is 30¼ pounds, and the number of its parts is 30. The cartridge when 7½ inches from its seat in the chamber can be pushed home by the breechblock in closing.

It is claimed that this mechanism has the advantage of applicability to existing guns with the interrupted screw fermeture. This claim would need verification in the case of any particular gun. No reason is seen for doubting it.

Starting with the breechblock closed, the mechanism was removed and dismantled by 1 man in 6 minutes 37⅘ seconds, using screwdriver, wrench, hammer, and copper drift. The mechanism was assembled, replaced in the gun, and the motion of firing executed in 12 minutes 12⅔ seconds.

A test was made of the time required for firing a round, removing and replacing the mainspring, sear spring, firing pin, and extractor and firing a second round. The time between the two reports was 5 minutes and 5 seconds, but there were two missfires, caused probably by the mainspring being in upside down.

The gun was mounted upon a nonrecoil mount, and closing the block would disturb the aim both in elevation and direction.

For much of the firing reloaded ammunition was used, which, by the failure of the cartridge cases, caused a great deal of difficulty and increased the severity of the test of the gun.

VELOCITY.

The maximum velocity determined by firing 5 rounds of reloaded ammunition was 1,769 foot seconds, the minimum 1,760 foot seconds, and the mean 1,763 foot seconds. There was 1 missfire in the 5 rounds.

ACCURACY.

At 1,000-yard range 1 sighting shot was fired, and then 10 at the target, of which all were hits, the mean vertical deviation from the center of impact being 0.858 foot; the mean horizontal deviation 1.39 feet, and the mean deviation 1.635 feet.

At the first attempt to make a target at 1-mile range, using reloaded ammunition, 5 rounds were fired; at the first and last rounds the car-

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mechanism, although powder gas came back through it, but after the last the block was opened with much difficulty by using a mallet, and the cartridge case was stuck so tightly in the bore that the extractor was bent in removing it. The firing pin was also found to be broken and the extractor lever twisted. The firing was discontinued and the extractor repaired.

At the second attempt reloaded ammunition was also used. Seven sighting shots were fired, then 10 at the target, all of which were hits, the deviations being: Mean vertical, 3.72 feet; mean horizontal, 2.92 feet; mean, 4.729 feet.

Three cartridge cases cracked, causing an escape of gas, but causing no inconvenience except some difficulty in opening the block after the eleventh round.

At the first attempt to make a target at 3,000-yard range, reloaded ammunition was used, but 22 sighting shots showed firing with this ammunition to be too inaccurate, and the attempt was postponed.

At the second attempt, using fresh ammunition, 3 rounds were fired, when the firing was suspended on account of haze.

At the third attempt, using fresh ammunition, 6 sighting shots were fired, then 10 at the target, of which 3 were misses; the deviations of the 7 hits were: Mean vertical, 6.18 feet; mean horizontal, 7.27 feet; mean, 9.54 feet.

A representation of the targets is inclosed. Plate VII.

The sight is not graduated and has no drift scale attached.

RAPIDITY.

The number of rounds fired in 5 seconds was: At the first trial, 1; at the second trial, 1 and 1 missfire; at the third trial, 2, at the last of which the lanyard was broken.

The number of rounds fired in 1 minute was 12 and in 3 minutes 35; the number 12 being that fired in the first minute of 3-minute test. There were 9 missfires, 4 being in the first minute, after each of which the piece had to be cocked, the missfires not being counted as rounds fired. They were probably due to insufficient strength of the mainspring.

The officers loading and firing exchanged places at the end of 1½ minutes.

The time required for firing 100 rounds was 11 minutes 34¾ seconds. This time was increased by 48 missfires, 29 requiring a second trial, 3 a third trial, and 2 seventeen trials to explode the primers. The missfires were due to weakness of mainspring. Also the 3 screws holding the rotating piece to the breechblock had to be tightened 4 times, all of which time was included in that required to fire the 100 rounds. The ammunition used was reloaded, and there were 15 instances in which the cases cracked and gas escaped into the mechanism. As a consequence of the fouling the breech was opened with some difficulty in the last 32 rounds. After the completion of the firing soft solder melted all along the chase, and the paint scaled off; temperature probably about 375° F.

The ammunition was placed on a table in rear of the gun and close to it. Three persons served the piece, two officers loading and firing, and one enlisted man passing ammunition. The officers loading and firing exchanged places after firing 50 rounds.

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Two sighting shots were fired at 1,000 yards range, and then 10 at the target, all of which were hits, the deviations being: Mean vertical, 1.85 feet; mean horizontal, 2.8 feet; mean, 3.356 feet. One missfire occurred. The time required to fire the 10 rounds was 2 minutes 26½ seconds.

At 1 mile range 5 sighting shots were fired, then 10 at the target, all of which were hits, the deviations being: Mean vertical, 3.72 feet; mean horizontal, 3.47 feet; mean, 5.087 feet. The rim of 1 cartridge case was split; the case rammed out from the muzzle. The time for the 10 rounds was 4 minutes 56 seconds.

With two targets placed 80 feet apart, at 500 yards range, 3 sighting shots were fired, then 10 alternate shots at each target. For target No. 1 there were two misses, the deviations of the 8 hits being: Mean vertical, 1.344 feet; mean horizontal, 1.958 feet; mean, 2.375 feet. Upon target No. 2 there were 10 hits, of which the deviations were: Mean vertical, 1.717 feet; mean horizontal, 1.45 feet; mean, 2.247 feet. The time required for firing the 20 rounds was 4 minutes 22¼ seconds.

Ten alternate rounds were fired at each of 2 targets placed in line and at ranges of 500 and 1,000 yards. Upon the 500-yard target there were 9 hits, the deviations being: Mean vertical, 1.37 feet; mean horizontal, 2.428 feet; mean, 2.788 feet. Upon the 1,000-yard target there were 10 hits, the deviations being: Mean vertical, 3.10 feet; mean horizontal, 6.07 feet; mean, 6.81 feet. The time required for firing the 20 rounds was 6 minutes 4¼ seconds. There was one missfire. The sight was adjusted for each shot. A representation of the target is inclosed (Pl. VIII).

DUST.

The blue prints attached to the firing record show the method adopted for dusting the mechanism. "A" is a lead pipe leading from the pine box "C" to the hand bellows in the blacksmith shop. One blue print shows the apparatus at work; the other shows it at rest.

The gun, not cocked, was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable.

The dust used was burnt sand from the proof butts; the passage of projectiles through this sand converts it into something similar to clay in appearance, but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose.

After being dusted the gun was remounted and the time to open the breech and fire 5 rounds was noted.

Time, 16 minutes.

The breechblock was opened by one man at the first attempt, but the gun could not be fired. The mechanism was dismantled and the parts washed.

There was very little dust in the mechanism and none in the bore.

Five rounds instead of 20 were fired on account of scarcity of ammunition.

EXCESSIVE PRESSURES.

In the 5 rounds fired reloaded ammunition was used, the normal charge used being 31 ounces of U. F. powder, lot 8; to this was added in the 5 cases, 1 ounce, 2 ounces, 2 ounces, 1½ ounces, and 1¾ ounces of rifle powder, the pressures being, respectively, 40,760, 50,429, 59,400,

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Defective cartridges prepared in three ways were used. In the first case, the cartridge case was prepared by filing obliquely through the edge of the rim so as to just show an opening to the interior at the junction of the wall and head. The slots are at the extremities of two diameters placed at right angles with each other. The cartridge was placed in the gun so that the solid part of the rim came opposite the extractor.

There was quite an escape of gas, as a matter of course, and the block could not be opened by hand; the handle was tapped with a mallet until block began to rotate; it then opened by hand without difficulty.

The second cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other and each was half way between the primer and rim. There was a decided escape of gas into all parts of the mechanism. The firing pin was forced back against the mainspring, compressing the latter so much that the gun was found cocked after firing.

The breechblock could not be opened by hand nor by using a mallet on the handle. At the end of twelve minutes an effort was made to dismantle the mechanism without opening the block, but the screws which hold the rotating piece to the breechblock could not be removed. The gun was then elevated and water poured into the muzzle until it ran out through the block to soften the residue. The breech mechanism was then dismantled, cleaned, and replaced, the breechblock still remaining in the gun. By using a mallet on the handle the block was then opened. The empty case was extracted without difficulty.

A service cartridge afterwards failed 14 times, due probably to the weakening of the mainspring by the gas from the previous round. The breech mechanism was again dismantled and the play of the mainspring was decreased by inserting a washer three-thirty-seconds inch thick. After four missfires a service round was then fired. Time, 3 hours, 32 minutes.

Blowbacks were made by unloading the requisite number of rounds, decapping the cases, and thinning the metal of the primers; the cases were then recapped and the charges replaced.

One blowback was fired at the first attempt. The breechblock opened easily.

With the second blowback the firing pin was so fouled by residue from the preceding round that it would not work. Water was thrown over the block to soften the residue, and the round was then fired. The block was opened by using a mallet on the handle.

The third blowback failed after repeated trials, water having been poured on the block in the meantime. Upon dismantling the mechanism the firing pin was found slightly bent. Time occupied, 23 minutes.

The test was resumed at 8 o'clock a. m. on the following day. The bent firing pin was broken at the machine shop in trying to straighten it. A new one was substituted. The new pin differed slightly from the old one in dimensions and the gun could not be cocked until the

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After 5 missfires with the third blowback a new Maxim-Nordenfelt cartridge was tried and failed 5 times. A reloaded cartridge was tried and fired. A new blowback was ordered.

The fourth blow back was fired at the first attempt. The gun was cocked by the blow back.

The breechblock was opened easily by using a mallet on the handle.

With a service cartridge there were then 5 missfires. The block was opened and water poured over it; it was then opened and closed a number of times and snapped each time to force the residue from around the firing pin. The cartridge was tried again and missed fire 6 times. The mechanism was dismantled, the parts cleaned and replaced. It still failed to work and a new firing pin was substituted. Four missfires followed. The mechanism was again dismantled and all parts found in good order. A burr was finally noticed in the slot in the handle through which the firing pin works. This retarded the pin. It was removed. After one more missfire the round was finally fired.

Time to fire 3 blow backs and 2 service cartridges, 2 hours and 30 minutes.

RUST.

The breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap.

The gun, not cocked, was immersed in a solution of 15 per cent sal ammoniac and 85 per cent water by weight; it was suspended with the axis vertical and was lowered into the solution just enough to cover the breech mechanism, and remained for 25 minutes.

Before immersing, a soft wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber.

After rusting for 48 hours the block could not be opened by hand, but was opened by using a mallet on the handle.

The mechanism was dismantled and the parts at once immersed in coal oil.

The pistol grip was found bent so that the trigger lever could not reach the sear; straightened.

Time to open block and fire 5 rounds, 32 minutes.

During the test the gun showed several defects naturally incident to a new and comparatively untried design. The mainspring was too weak, and the new one substituted after the two hundredth round did not prevent the recurrence of missfires. The screws holding the rotating piece to the breechblock could not be kept tightly in place for any length of time, and the pin holding the cocking piece to the firing pin would also come out.

Drawings received from the inventor show projected improvements in the mechanism, but their discussion would be out of place in this report.

The firing and loading were performed by Lieut. M. F. Harmon, First Artillery, and Lieut. F. P. Peck, Ordnance Department.

The following table gives a summary of the general results of the test, which was concluded on August 8 last, 323 rounds being fired:

Weight	pounds..	760
Caliber	inches..	2.244
Length	calibers..	46.1
Weight of breech mechanism	pounds..	30¼
Number of parts of breech mechanism		30

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Time to dismantle breech mechanism 6m 37⅘s
Time to assemble breech mechanism 12m 12⅗s
Distance from seat in chamber at which breechblock will force cartridge home .....inches.. 7⅛
Time to fire one round, change mainspring, sear spring, firing pin, and extractor, and fire another round..... 8m 51s
Time to fire 100 rounds..... 11m 34⅘s
Number of rounds fired in 1 minute..... 12
Number of rounds fired in 3 minutes..... 35
Number of rounds fired in 5 seconds, first trial..... 1
Number of rounds fired in 5 seconds, second trial..... 1
Number of rounds fired in 5 seconds, third trial..... 2
Time to fire 2 defective and 1 service cartridge..... 3h 32m
Time to fire 5 rounds after dusting, first test.....minutes.. 16
Time to fire 5 rounds after dusting, second test (not tested).....
Time required to fire 3 blowbacks and 1 service cartridge..... 2h 30m
Time required to open breechblock and fire 5 rounds after rusting, minutes..... 32
Mean velocity .....foot-seconds.. 1,763

	Accuracy.			Accuracy with rapidity.		Alternating two 500 yards.		Alternating 500 and 1,000 yards.	
	1,000 yards.	1 mile.	3,000 yards.	1,000 yards.	1 mile.	No. 1.	No. 2.	500 yards.	1,000 yards.
Mean vertical deviation....feet..	0.86	3.72	6.18	1.85	3.72	1.34	1.72	1.37	3.10
Mean horizontal deviation. do...	1.39	2.92	7.27	2.8	3.47	1.96	1.45	2.43	6.07
Mean deviation.....do...	1.64	4.73	9.54	3.36	5.09	2.38	2.25	2.79	6.81
Number of hits.....	10	10	7	10	10	10	8	9	10
Number of misses	0	0	3	0	0	0	2	1	0
Time to fire	.....	.....	.....	2m 26⅕s	4m 56s	.....	.....	.....	.....
Time to fire, both targets.....	.....	.....	.....	.....	.....	4m 22⅕s		6m 4⅕s	

Firing record and 8 plates are inclosed.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army,
President.

FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3164)

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[Objective firing.

Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength and direction.
				Feet.	*Pounds.*		
July 6	1	Armor piercing, lot 571.					
July 6	2			1,767 1,771			
July 6	3			1,756 1,764			
July 6	4			1,761 1,766			
July 6	5			1,763 1,758			
July 6	6			1,761 1,762			
				50+1⅛°			
July 17	7	Reloaded					

[To fire one round, dismount block, change mainspring, searspring

July 17	8						
July 17	9						

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Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Warming charge, fired to sea. Reloaded ammunition.	This gun is 46.1 calibers long from seat of head of cartridge case to muzzle.
1 missfire. Case dished near choke. Crack in dish.	Weight of breechblock and breech mechanism complete, including hinge pin and sight, 30½ pounds.
One missfire.....	Starting with the breechblock closed, the breech mechanism was removed and dismantled by 1 man in 6 minutes 37¾ seconds, using a screwdriver, wrench, hammer, and copper drift.
.....	The mechanism was assembled, replaced in the gun, and the motion of firing executed in 12 minutes 12⅗ seconds.
.....	The breech mechanism of this gun consists of 30 parts.
.....	The gun was fired from a nonrecoil mount and the shock was so severe that it was not possible to fire from the shoulder, and the firing was all done by means of a short lanyard attached to the trigger.
.....	Lieuts. Harmon, First Artillery, and Peck, Ordnance Department, did all the loading and firing.
Handle of sight found broken after this round.	The time was taken by the proof officer, using a stop watch which reads to one-fifth of a second.
	The breech block will force the cartridge home when it is 7⅛ inches short of its seat in chamber.
	Closing the block disturbs the aim in both elevation and direction.
	There was no representative of this gun present during the test.
Went in hard. Fired into sand butt.....	Cylinder filled with glycerin and water.

firing pin, and extractor, mount and fire another round.]

1 missfire.....	These three missfires were probably due to the mainspring being in upside down.
2 missfires	Done in 8 minutes and 51 seconds by Lieut. M. F. Harmon, First Artillery.

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
July 18	10	Reloaded ammunition.	4 47			1	Wind front and left, 10°, 11 miles an hour.
July 18	11		4 45			1	
July 18	12		4 40			1	
July 18	13		4 41			1	
July 18	14		4 41				
July 18	15		4 40½				Wind front and left, 15°, 15 miles an hour.
July 18	16		4 39½				
July 18	17		4 38				
July 18	18		4 38				Wind front and right, 15°, 17 miles an hour.
July 18	19		4 38				
July 18	20		4 38				
July 18	21		4 38				
July 18	22		4 38				Wind front and right 20°, 16 miles an hour.
July 18	23		4 38				
July 18	23		4 38				
July 18	24		4 38				
July 18	25		4 38				
July 18	26		4 38				
July 18	27		4 38				
July 18	28		4 38				
July 18	29		4 37½				
July 18	30		4 37½				

[For accuracy

July 19	31	Reloaded ammunition.	2 16				Wind right and rear, 30°, 12 miles an hour; barometer, 30.19; thermometer, 91°; humility, 53.
July 19	32		2 16				
July 19	33		2 16				
July 19	34		2 15				
July 19	35		2 15				

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ounds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

t 3,000 yards.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Struck 200 yards beyond and to the left	
Struck 190 yards beyond—good line	
Struck 9 feet below and 9 inches left of center.	
Miss, could not be located	
Struck target 13½ feet above and 1½ feet left of center	
Struck 150 yards beyond and 10 feet right of center.	
Struck 150 yards beyond	
Struck 8½ feet below and 12½ feet left of center.	
	Aimed to the left of the left edge.
	Target can not be seen at all; even a board nailed to the left edge and projecting above its top being invisible, due to the intervening undergrowth.
Struck 200 yards in front, ricochetted over	
Struck 30 yards beyond and 5 ft. left of target.	
Struck 8 feet 2 inches above and 8 feet 2 inches left of center.	
Struck 100 yards in rear and left	
	Rear sight not graduated at all, and no drift scale on it.
	Target not platted.
	Barometer, 30.29; thermometer, 85°; humidity, 56.
Struck 8½ feet below and 8 feet left of center.	
Struck 2 feet above and 9½ feet left of center.	
Struck 10 feet 8 inches above and 9 feet right of center.	
Struck 75 yards beyond	
Struck 300 yards in front	
Struck 100 yards in rear	
Struck 8 feet below, 4 feet left of center	
Struck 100 yards beyond	
Struck 10 feet below, 1½ feet left of center	
Struck 215 yards in front	

at 1 mile.]

Aimed at the upper left corner. Powder gas came out through block, striking operator in the face. Breechblock opened and cartridge case ejected without difficulty. Cartridge case split from edge of rim toward primer and along cylindrical portion in two places. Struck target 2½ feet above and 12 feet 9 inches left of center.	
Aimed at middle of top of target. Breech mechanism not cleaned; worked without difficulty. Struck 8 feet above and 3 feet left of center.	
Aimed as before. Missed fire once. Missed target; went to sea.	
Aimed as in round 32. Struck target 11 feet above, 9 feet 8 inches left of center.	
Aimed as in round 32. Struck target 11 feet 8 inches above, 6 feet 2 inches left of center. Breechblock opened with mallet with much difficulty. The empty case was extracted and ejected by means of the mechanism alone, but the test was an extremely severe one, and bent the extractor so much that the breechblock could not be closed. There were 4 holes and 4 cracks on the head and body of the case similar to those found in round 31. Screws in rotator loose. Breech mechanism partly dismantled, cleaned, and oiled. Firing pin found broken in first thread where the point screwed to the larger part. Extractor lever (too soft) found twisted. Firing discontinued at 11 a. m., and extractor sent to machine shop for repairs.	

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength and direction.
			° ′	*Feet.*	*Pounds.*		
July 20	36						
July 20	37						
July 20	38						
July 20	39 to 40						

[For rapidity,

July 20	41 to 140						

[For rapidity, 1 and

July 24	141 to 176						

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Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Fired to sea to note the place of striking. Number of rounds fired in 5 seconds, first trial, 1. Number of rounds fired in 5 seconds, second trial, 1 and 1 missfire. Number of rounds fired in 5 seconds, third trial, 2; lanyard broken.	The 3 screws which hold the rotating piece to the rear end of the breechblock tightened after these 5 rounds.

100 rounds.]

Time to fire 100 rounds, 11 minutes 34½ seconds. In this test there were 29 instances in which the primer failed at the first trial. In 3 of these 29 failures it failed twice, and in 2 others it failed 16 times. As a consequence of these failures the gun had to be recocked 62 times. The time consumed in doing this is included in the time required to fire 100 rounds. The 3 screws which hold the rotating piece to the rear end of the breechblock had to be tightened 4 times during this firing. The time consumed is included as part of the time necessary to fire the 100 rounds. There were 15 rounds in which cracks developed in the case and gas escaped into the mechanism. In consequence of the fouling thus produced, the breechblock opened with some difficulty after 68 rounds had been fired. Both eyebolts for holding shoulder piece to gun broke off at first thread. Two bolts holding the empty case deflector to the shoulder bar were broken off and 2 loosened during this firing. Soft solder melted and all the paint scaled from the chase. (The exterior of this gun was bright at the beginning of the test, but it was afterwards painted with the service paint for field and siege artillery.) Reloaded ammunition used in this test.	In firing for rapidity, the ammunition was placed on a table in rear of the gun and as close to it as possible without interfering with the handling of the gun. Taking the ammunition from this table 3 men served the gun. Lieuts. Harmon and Peck alternated in loading and firing, changing at the end of 1.5 minutes in the 3-minute test, and after 50 rounds in the 100-round test.

3 minute tests.]

Rounds fired in 1 minute, 12; rounds fired in 3 minutes, 35. The number of rounds fired in 1 minute was determined by noting the number fired in the first minute of the 3-minute test. There were 9 missfires, 4 of these being in the first minute. The missfires are the number of times the gun had to be recocked. The missfires are probably due, in this case at least and probably in all others also, to insufficient strength of the mainspring. There was no case throughout the test, except with this gun, in which a round of new ammunition failed to fire at the first attempt when fairly struck unless the breech mechanism was out of order. Missfires due to pulling the trigger too soon are impossible with this gun, because the trigger can not come in contact with the sear until the block is closed and locked.	

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Record of firing with Seabury 6-pounder rapid-fire gun (weight, with block

[Excess

Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind strength and direction.
			° ′	*Feet.*	*Pounds.*		
July 25	177				4, 37, 467		
July 25	178				10, 40, 760		
July 25	179				4, 50, 429		
July 25	180				10, 59, 400		
July 25	181				4, 44, 127		
July 25	182				10, 35, 000		
July 25	183				4, 58, 433		

[Test v

July 25	184						
July 25	185						
July 25	186						

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Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
1 misfire. Service charge	Copper cylinder of 32,000 pounds initial compression and tables of 1892.
1 misfire. 1 ounce rifle powder added to charge.	
2 ounces rifle powder. Block dismantled and cleaned.	
2 misfires. 2 ounces rifle powder	Reloaded ammunition. 31 ounces U. F., lot 8.
1 misfire 1½ ounces rifle powder	Copper cylinders of 40,000 pounds initial compression and tables of 1893.
Service charge. Copper cylinder of 32,000 pounds initial compression and tables of 1890.	
1 misfire. 1¾ ounces rifle powder	

defective cartridges.]

The cartridge case was prepared by filing obliquely through the edge of the rim, so as to just show an opening to the interior at the junction of the head and wall. The slots are at the extremities of 2 diameters placed at right angles with each other. Cartridge placed in gun so that the solid part of the rim came opposite the extractor. There was quite an escape of gas as a matter of course, and block could not be opened by hand. Handle tapped with a mallet until block began to rotate. It then opened by hand without difficulty.	
The cartridge case was prepared by sawing slots through the head so as to just show an opening to the interior. The slots were at right angles with each other and each was half way between the primer and the rim. There was a decided escape of gas into all parts of the mechanism. The firing pin was forced back against the mainspring, compressing the latter so much that the gun was found cocked after firing. The breechblock could not be opened by hand nor by using a mallet on the handle. At the end of 12 minutes an effort was made to dismantle the mechanism without opening the block, but the screws which hold the rotating piece to the breechblock could not be removed. The gun was then elevated and water was poured into the muzzle until it ran out through the block to soften the residue. The breech mechanism was then dismantled, cleaned, and replaced, the breechblock still remaining in the gun. By using a mallet on the handle the block was then opened. The empty case was extracted without difficulty.	
A service cartridge failed 14 times, due, probably, to the weakening of the mainspring by the gas from the previous round. The breech mechanism was again dismantled and the play of the mainspring was decreased by inserting a washer three thirty-seconds of an inch thick. After 4 misfires a service round was then fired. Time, 3 hours 32 minutes.	

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Record of firing with Seabury 6-pounder rapid-fire gun (weight, with bl

Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	W
			° ′	*Feet.*	*Pounds.*		
July 25	187						
July 25	188						
July 25	189						
July 26	190						
July 26	191						
July 26	192 to 195						

[Dust test,

July 27	196 to 200						

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unds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

st.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Blowback. Fired at first attempt. Breechblock opened easily.	The blowbacks were secured by unloading the requisite number of rounds, decapping the cases, and thinning the metal of the primers. The cases were then recapped and the charges replaced.
Blowback. The firing pin was so fouled by residue from round 187 that it would not work. Water was thrown over the block to soften the residue and the round was then fired. The block was opened by using a mallet on the handle.	
Blowback. Failed after repeated trials, water having been poured on block in the meantime. Upon dismantling the mechanism the firing pin was found slightly bent. Test suspended at 5:18 p. m. Began blowback test 4:55 p. m. Time elapsed, 23 minutes.	
Blowback. Fired at first attempt. Gun cocked by the blowback. Breechblock opened easily by using a mallet on the handle.	
Service cartridge, 5 misfires. The block was opened and water poured over it. It was then opened and closed a number of times and snapped each time to force the residue from around the firing pin. The cartridge was tried again and missed fire 6 times. The mechanism was dismantled, the parts cleaned and replaced. It still failed to work and a new firing pin was substituted. Four misfires followed. The mechanism was again dismantled and all parts found in good order. A burr was finally noticed in the slot in the handle through which the firing pin works. This retarded the pin. It was removed. After one more misfire the round was finally fired. Time to fire 3 blowbacks and 2 service cartridges, 2 hours and 30 minutes.	Test resumed at 8 o'clock a. m. The bent firing pin was broken at the machine shop in trying to straighten it. A new one was substituted. The new pin differed slightly from the old one in dimensions and the gun could not be cocked until the washer heretofore placed in front of the mainspring was made thinner by one-thirty-second of an inch. After 5 misfires with the third blowback a new Maxim-Nordenfelt cartridge was tried and failed 5 times. A reloaded cartridge was tried and fired. A new blowback was ordered.
Fired to sea.....	

ıot cocked.]

The breechblock was opened by 1 man at the first attempt, but the gun could not be fired. The mechanism was dismantled and the parts washed. There was very little dust in the mechanism and none in the bore.	The attached blue prints show the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. One blue print shows the apparatus at work, the other shows it at rest. The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable. The dust used was burnt sand from the proof butts; the passage of projectiles through this sand converts it into something similar to clay in appearance but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose. After being dusted the gun was remounted and the time to open the breechblock and fire 5 rounds was noted. Time, 16 minutes.

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Record of firing with Seabury 6-pounder rapid-fire gun (weight, with block,

[For accuracy

Date.	No. of fire.	Porjectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of miss-fires.	Wind, strength, direction, etc.
			° ′	*Feet.*	*Pounds.*		
July 30	201	Reloaded ammunition.	2 15				Wind from right and rear 45°, 8 miles an hour; barometer, 30.31; thermometer, 80°; humidity, 70.
July 30	202		2 14				
July 30	203		2 14				
July 30	204		2 14				
July 30	205		2 14				
July 30	206		2 14				
July 30	207		2 12				
July 30	208		2 10				
July 30	209						
July 30	210						
July 30	211						
July 30	212						
July 30	213						
July 30	214						
July 30	215						
July 30	216						
July 30	217						

[For rapidity of

July 30	218						Wind right and rear 45°, 6 miles an hour; barometer, 30.12; thermometer, 92°; humidity, 48.
July 30	219						
July 30	220						
July 30	221						
July 30	222						
July 30	223						
July 30	224						
July 30	225						
July 30	226						
July 30	227						
July 30	228						
July 30	229						
July 30	230						
July 30	231						
July 30	232						

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Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Struck target 9 feet above and 5 feet right....	Aimed at the upper left corner.
Struck target 9 feet left of center.....	A new mainspring, received just before this firing, was substituted for the old one.
Miss, to the left. Gas escaped; case cracked.	
Struck target 5 feet above and 5 feet right....	
Struck target 11 feet above and 7 feet left. Gas escaped; case cracked.	
Miss, over; case cracked.....	
Struck target 8 feet above and 10 feet left....	

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
7	.....	.....	7	3.35	.....	.....	5.4
5	.....	.....	6	1.35	.....	.....	4.4
10	.....	0		6.35	.....	1.6	.....
8	.....	0		4.35	.....	1.6	.....
5	.....	2	.....	1.35	.....	3.6	.....
5.5	.....	2	.....	1.85	.....	3.6	.....
.....	2	1	.....	.....	5.65	2.6	.....
.....	2	0		.....	5.65	1.6	.....
0	.....	.....	3	.....	3.65	.....	1.4
0	.....	.....	5	.....	3.65	.....	3.4

Round 212, block opened with some difficulty.

Center of impact—	Feet.
Above	3.65
Left	1.6
Mean vertical deviation from center of impact	3.72
Mean horizontal deviation from center of impact	2.92
Mean deviation from center of impact	4.729

accuracy at 1 mile.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Struck target 5 feet above and 5 feet left. This shot was reported from the target as here recorded, but upon comparison with the down-the-beach "book" this shot was not found in the latter at all. Struck target 5 feet above and 5 feet left.	Aimed at the upper left corner.
Firing stopped to allow ships to pass. Struck target 11 feet left of center.	Screws holding rotating piece to the rear of the breechblock have to be tightened frequently.
Struck 6 feet above and 6 feet left of center.	Pin holding cocking piece to firing pin comes out.
Struck target 4 feet above and 6 feet left.	Can not be fired from the shoulder, punishment too great.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
11	.....	.....	8	8.1	.....	.....	4.55
.....	7	.....	4	.....	9.9	.....	0.55
0	.....	.....	2	.....	2.9	1.45	.....
5	.....	.....	4	2.1	.....	.....	0.55
4	.....	.....	8	1.1	.....	.....	4.55
6	.....	.....	3.5	3.1	.....	.....	0.05
0	.....	.....	6	.....	2.9	.....	2.55
5	.....	2	.....	2.1	.....	5.45	.....
0	.....	.....	8	.....	2.9	.....	4.55
5	.....	7	.....	2.1	.....	10.45	.....

At round 228 rim of case split and gas escaped through mechanism. Case rammed out from the muzzle.

Center of impact—	Feet.
Above	2.9
Left	3.45
Mean vertical deviation from center of impact	3.72
Mean horizontal deviation from center of impact	3.47
Mean deviation from center of impact	5.087

Time to fire 10 rounds, 4 minutes 56 seconds.

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| Date | | |

ounds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

t 3,000 yards.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
One misfire, struck 150 yards in rear, on line. Projectile irregular in flight.	
One misfire, struck 100 yards beyond 1-mile target. Projectile irregular in flight.	Firing suspended on account of haze.
Struck 170 yards beyond target.	

0 feet apart, alternating shot by shot on targets.]

Fired at No. 1 target. Struck 3½ feet above and 1 foot left of center.
Fired at No. 1 target. Struck 3 feet below center.
Fired at No. 2 target. Struck 3 feet below 1 foot left of center.

Aimed at bull's-eye.
After getting the proper elevation the rear sight was marked and the targets made by using this mark for elevation.
Locking pin of cocking piece flies out; found on platform twice to-day.
Smoke interfered very decidedly.

TARGET No. 1.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
3.5	.....	4.75	.....	0.823	.....	4.667	.....
1.833	.....	1.75	.....	.....	0.844	1.667	.....
1.75	.....	1.583	.....	.....	0.927	1.500	.....
4.583	.....	.....	0.167	1.906	.....	.....	0.250
0.75	.....	.....	1.167	.....	1.927	.....	1.250
1	.....	.....	1.083	.....	1.677	.....	1.166
3	.....	.....	1.5	0.328	.....	.....	1.583
5	.....	.....	3.5	2.323	.....	.....	3.583
Miss.....							
Miss.....							

Center of impact—	Feet.
Above	2.677
Right	0.083
Mean vertical deviation from center of impact.	1.344
Mean horizontal deviation from center of impact	1.958
Mean diviation from center of impact	2.375

Round 241, two misfires.

TARGET No. 2.

5.5	.....	3.167	.....	2.283	.....	3.375	.....
5.5	.....	2.583	.....	2.283	.....	2.701	.....
1.5	.....	0.667	.....	.....	1.717	0.875	.....
5.5	.....	.....	1	2.283	.....	.....	0.792
4.917	.....	.....	0.5	1.700	.....	.....	0.292
1.5	.....	0		.....	1.717	0.208	.....
3.25	.....	.....	1.5	0.033	.....	.....	1.292
1.833	.....	.....	1.5	.....	1.384	.....	1.292
1.833	.....	.....	2.5	.....	1.384	.....	2.292
0.833	.....	.....	1.5	.....	2.384	.....	1.292

Center of impact—	Feet.
Above	3.217
Left	0.208
Mean vertical deviation from center of impact.	1.717
Mean horizontal deviation from center of impact	1.45
Mean deviation from center of impact	2.247

Time to fire the 20 rounds, 4 minutes 22¼ seconds.

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of miss-fires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
Aug. 1	259		0 56				Wind front, 9 miles an hour; barometer, 30.11; thermometer, 85°; humidity, 68.
Aug. 1	260		0 56				
Aug. 1	261						
Aug. 1	262						
Aug. 1	263						
Aug. 1	264						
Aug. 1	265						
Aug. 1	266						
Aug. 1	267						
Aug. 1	268						
Aug. 1	269						
Aug. 1	270						

[For rapidity with accuracy at 500 and 1,000 yard targets

Aug. 1	271						Wind from front, 9 miles an hour; barometer, 30.11; thermometer, 85; humidity, 68.
Aug. 1	272						
Aug. 1	274						
Aug. 1	276						
Aug. 1	278						
Aug. 1	280						
Aug. 1	282						
Aug. 1	284						
Aug. 1	286						
Aug. 1	288						
Aug. 1	290						
Aug. 1	271						
Aug. 1	273						
Aug. 1	275						
Aug. 1	277						
Aug. 1	279						
Aug. 1	281						
Aug. 1	283						
Aug. 1	285						
Aug. 1	287						
Aug. 1	289						

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pounds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

racy at 1,000 yards.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Struck target 1 foot below and 25 feet left of center. Aimed at the upper left corner. Aimed at the top of target above bull's-eye. Struck 4 feet below and 10 feet left of center.	Smoke interfered.

TARGET.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
4.5		1		2.65		7.1	
2			1.75	0.15		4.35	
1.5			4.25		0.35	1.85	
3			5.5	1.15		0.6	
7			7	5.15			0.9
2			7	0.15			0.9
1			8		0.85		1.9
0.5			8.5		1.35		2.4
	0.5		6		2.35	0.1	
	2.5		14		4.35		7.9

Rear sight marked after round 261, and mark used to make the target.
Round 266, one misfire.

Center of impact—	Feet.
Above	1.85
Left	6.1
Mean vertical deviation from center of impact.	1.85
Mean horizontal deviation from center of impact	2.8
Mean deviation from center of impact	3.356

Time to fire the 10 rounds, 2 minutes 26½ seconds.

on the same line, alternating shot by shot on targets.]

TARGET, 1,000 YARDS.

From center of target.				From center of impact.			
Vertical.		Horizontal.		Vertical.		Horizontal.	
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.
4.25			0.25	3.375		6.375	
2.5			5.5	1.625		1.125	
0.5			5.667		3.75	0.958	
5			5	4.125		1.625	
5.5			6.5	4.625		0.125	
1.5			11.833	0.625			5.208
2			24	1.125			17.375
	2.5		14		3.375		7.375
	1		7		1.875		0.375
	9	13.5			9.875	2.125	

Aimed at bull's-eye for 500-yard target.
Aimed at top above bull's-eye for 1,000-yard target.
The marks previously made on the sight for these ranges were used in making these targets.
The sight was adjusted after each shot.

Center of impact—	Feet.
Above	0.875
Left	6.625
Mean vertical deviation from center of impact.	3.100
Mean horizontal deviation from center of impact	6.07
Mean deviation from center of impact	6.81

Round 288, 1 misfire.

TARGET, 500 YARDS.

4.5		4.833		1.75		6.148	
3.833		1.167		1.083		2.482	
4.333		0.25		1.583		1.565	
2			0.583		0.75	0.732	
0.833			2.5		1.917		1.185
2.417			2.167		0.333		0.852
4.5			2.5	1.75			1.185
0			4.583		2.75		3.268
2.333			5.75		0.417		4.435

Miss

Center of impact—	Feet.
Above	2.75
Left	1.315
Mean vertical deviation from center of impact.	1.37
Mean horizontal deviation from center of impact	2.428
Mean deviation from center of impact	2.788

Time to fire the 20 rounds, 6 minutes 4¼ seconds.

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
Aug. 2	291	Lot 532.	4 35				Wind front and left, 45°, 4 miles an hour; barometer, 30.02; thermometer, 79°; humidity, 83.
Aug. 2	292		4 35				
Aug. 2	293		4 33				
Aug. 2	294		4 32				
Aug. 2	295		4 30				
Aug. 2	296		4 31				
Aug. 2	297						
Aug. 2	298						
Aug. 2	299						
Aug. 2	300						
Aug. 2	301						
Aug. 2	302						
Aug. 2	303						
Aug. 2	304						
Aug. 2	305						
Aug. 2	306						

[For accuracy

Aug. 3	307	Lot 571.	0 56				
Aug. 3	308		1 10				From rear, 6 miles an hour.
Aug. 3	309		1 10				
Aug. 3	310		1 10				
Aug. 3	311		1 10				From left and front, 7 miles an hour.
Aug. 3	312		1 10				
Aug. 3	313		1 10				
Aug. 3	314		1 10				From front, 8 miles an hour.
Aug. 3	315		1 10				
Aug. 3	316		1 10				
Aug. 3	317		1 10				

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of miss-fires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
Aug. 6							
Aug. 8	318 to 322						

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength and direction.
			° ′	*Feet.*	*Pounds.*		
July 25	187						
July 25	188						
July 25	189						
July 26	190						
July 26	191						
July 26	192 to 195						

[Dust test, gun

July 27	196 to 200						

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pounds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

test.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Blowback. Fired at first attempt. Breechblock opened easily.	The blowbacks were secured by unloading the requisite number of rounds, decapping the cases, and thinning the metal of the primers. The cases were then recapped and the charges replaced.
Blowback. The firing pin was so fouled by residue from round 187 that it would not work. Water was thrown over the block to soften the residue and the round was then fired. The block was opened by using a mallet on the handle.	
Blowback. Failed after repeated trials, water having been poured on block in the meantime. Upon dismantling the mechanism the firing pin was found slightly bent. Test suspended at 5:18 p. m. Began blowback test 4:55 p. m. Time elapsed, 23 minutes.	
Blowback. Fired at first attempt. Gun cocked by the blowback. Breechblock opened easily by using a mallet on the handle.	
Service cartridge, 5 missfires. The block was opened and water poured over it. It was then opened and closed a number of times and snapped each time to force the residue from around the firing pin. The cartridge was tried again and missed fire 6 times. The mechanism was dismantled, the parts cleaned and replaced. It still failed to work and a new firing pin was substituted. Four missfires followed. The mechanism was again dismantled and all parts found in good order. A burr was finally noticed in the slot in the handle through which the firing pin works. This retarded the pin. It was removed. After one more missfire the round was finally fired. Time to fire 3 blowbacks and 2 service cartridges, 2 hours and 30 minutes.	Test resumed at 8 o'clock a. m. The bent firing pin was broken at the machine shop in trying to straighten it. A new one was substituted. The new pin differed slightly from the old one in dimensions and the gun could not be cocked until the washer heretofore placed in front of the mainspring was made thinner by one-thirty-second of an inch. After 5 missfires with the third blowback a new Maxim-Nordenfelt cartridge was tried and failed 5 times. A reloaded cartridge was tried and fired. A new blowback was ordered.
Fired to sea.....	

not cocked.]

The breechblock was opened by 1 man at the first attempt, but the gun could not be fired. The mechanism was dismantled and the parts washed. There was very little dust in the mechanism and none in the bore.	The attached blue prints show the method adopted for dusting the mechanism. A is a lead pipe leading from the pine box C to the hand bellows in the blacksmith shop. One blue print shows the apparatus at work, the other shows it at rest. The gun was subjected to a blast of dust for 8 minutes, 2 men working on the bellows as uniformly as practicable. The dust used was burnt sand from the proof butts; the passage of projectiles through this sand converts it into something similar to clay in appearance but it retains considerable grit. This was dried over the boiler. It pulverizes readily when dry and answered well for this purpose. After being dusted the gun was remounted and the time to open the breechblock and fire 5 rounds was noted. Time, 16 minutes.

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(For accuracy

Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength and direction
			° ′	*Feet.*	*Pounds.*		
[illegible]	201	Reloaded ammunition.	2 15				Wind from right and rear, 45°, 8 miles an hour; barometer, 30.31; thermometer, 80°; humidity, 79.
[illegible]	202		2 14				
[illegible]	203		2 14				
[illegible]	204		2 14				
[illegible]	205		2 14				
[illegible]	206		2 14				
[illegible]	207		2 12				
July 30	208		2 10				
July 30	209						
July 30	210						
July 30	211						
July 30	212						
July 30	213						
July 30	214						
July 30	215						
July 30	216						
July 30	217						

(For rapidity with

July 30	218						
July 30	219						
July 30	220						
July 30	221						
July 30	222						
July 30	223						Wind right and rear 45°, 8 miles an hour; barometer, 30.12; thermometer, 92°; humidity, 48.
July 30	224						
July 30	225						
July 30	226						
July 30	227						
July 30	228						
July 30	229						
July 30	230						
July 30	231						
[illegible]	232						

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
Aug. 1	233	Maxim-Nordenfelt, lot 552.	4 37½				
Aug. 1	234		4 35				
Aug. 1	235		4 35				

[For accuracy with rapidity at two 500-yard targets placed

Aug. 1	236		0 35				Wind from front, 9 miles an hour; barometer, 30.11; thermometer, 80°; humidity, 68.
Aug. 1	237		0 35				
Aug. 1	238		0 35				
Aug. 1	239						
Aug. 1	241						
Aug. 1	243						
Aug. 1	245						
Aug. 1	247						
Aug. 1	249						
Aug. 1	251						
Aug. 1	253						
Aug. 1	255						
Aug. 1	257						
Aug. 1	240						
Aug. 1	242						
Aug. 1	244						
Aug. 1	246						
Aug. 1	248						
Aug. 1	250						
Aug. 1	252						
Aug. 1	254						
Aug. 1	256						
Aug. 1	258						

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Wind from front, 9 miles an hour; barometer, 30.11; thermometer, 80; humidity, 68.

Fire rapidly with accuracy at 500 and 1,000 yard targets

Wind from front, 9 miles an hour; barometer, 30.11; thermometer, 80; humidity, 68.

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Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind, strength, and direction.
			° ′	*Feet.*	*Pounds.*		
Aug. 2	291	Lot 532.	4 35				Wind front and left, 4½ miles an hour; barometer, 30.02; thermometer, 79°; humidity, 83.
Aug. 2	292		4 35				
Aug. 2	293		4 33				
Aug. 2	294		4 32				
Aug. 2	295		4 30				
Aug. 2	296		4 31				
Aug. 2	297						
Aug. 2	298						
Aug. 2	299						
Aug. 2	300						
Aug. 2	301						
Aug. 2	302						
Aug. 2	303						
Aug. 2	304						
Aug. 2	305						
Aug. 2	306						

[For accuracy

Aug. 3	307	Lot 571.	0 56				
Aug. 3	308		1 10				From rear, 6 miles an hour.
Aug. 3	309		1 10				
Aug. 3	310		1 10				
Aug. 3	311		1 10				From left and front, 7 miles an hour.
Aug. 3	312		1 10				
Aug. 3	313		1 10				
Aug. 3	314		1 10				From front, 8 miles an hour.
Aug. 3	315		1 10				
Aug. 3	316		1 10				
Aug. 3	317		1 10				

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Record of firing with Seabury 6-pounder rapid-fire gun (weight, with block, 70

[Rust test, gu

Date.	No. of fire.	Projectile.	Elevation.	Instrumental velocity, 125 feet from muzzle.	Pressure, per square inch of bore.	Number of misfires.	Wind strength and direction
			° ′	*Feet.*	*Pounds.*		
Aug. 6							
Aug. 8	318 to 322						

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pounds), at Sandy Hook Proving Ground, July 6 to August 8, 1894—Continued.

not cocked.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
	The breech mechanism was dismantled and all the parts thoroughly cleaned by washing with hot water and soap. The gun was immersed in a solution of 15 per cent sal ammoniac and 85 per cent of water by weight. It was suspended with the axis vertical, and was lowered into the solution just enough to cover the breech mechanism, and remained for 25 minutes. Before immersing, a soft wood plug wrapped with a piece of cartridge-bag material, the latter smeared with cosmoline, was driven tightly into the rear end of the barrel to prevent unnecessary rusting of the chamber.
Started to open block 3:11 o'clock. The block could not be opened by hand, but was opened by using a mallet on the handle. The mechanism was dismantled and the parts at once immersed in coal oil. The pistol grip was found bent so that the trigger lever could not reach the sear; straightened. Time to open block and fire 5 rounds, 32 minutes. Total number of rounds fired 323 (see round 23′ accidentally omitted originally).	
	Firing conducted in the presence of the Ordnance Board. Present: Maj. F. H. Phipps, Ordnance Department; Capt. F. Heath, Ordnance Department; Capt. W. Crozier, Ordnance Department.

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S. SEABURY.

BREECH LOADING CANNON.

Fig. 1.

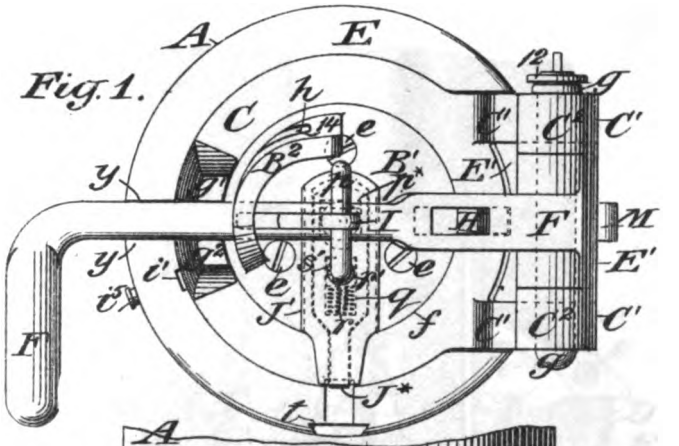


Fig. 2

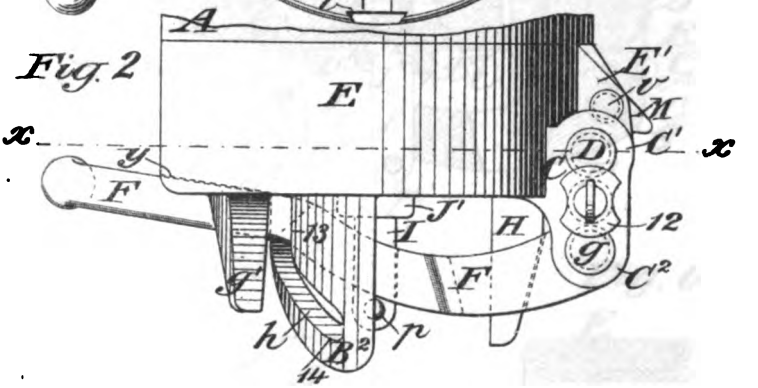
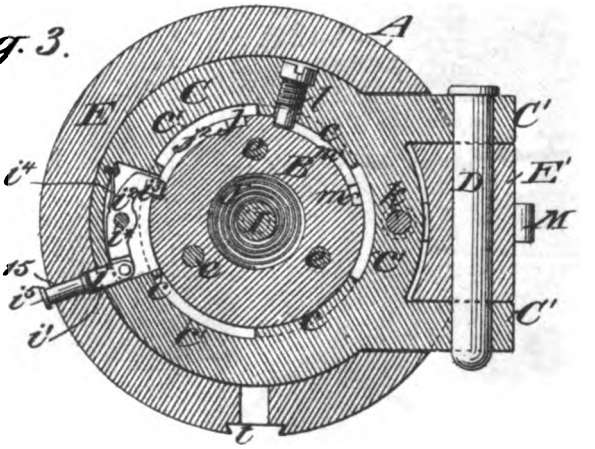


Fig. 3.



Appendix 38 D, 1894.

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APPENDIX 34.

TEST OF SPIRAL SPRINGS FOR SPRING-RETURN MORTAR CARRIAGE.

(1 plate.)

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL, GOVERNORS ISLAND,
NEW YORK HARBOR,
New York City, December 1, 1893.

SIR: The following report upon the test of spiral springs in the spring-return carriages for 12-inch mortars is respectfully submitted.

Each spring consists of a double coil of round bars, the elements coiled in opposite directions.

Diameter of bar of exterior coil	inches..	1.75
Diameter of bar of interior coil	do...	1.25
Exterior diameter of spring	do...	9
Interior diameter of spring, about	do...	3
Height of one spring free	do...	13.5
Height of one spring under 18,000 pounds load	do...	12.25
Height of one spring closed down	do...	9.75
Weight of one spring	pounds..	112

Between each two springs is placed a wrought-iron separating plate one-eighth of an inch thick, with flanges turned up and down.

The test of the springs was carried on in conjunction with the proof of mortars and carriages and other current firing.

The following rounds were fired:

Number of rounds.	With the cast-iron mortar.		Number of rounds.	With the steel mortar.	
	Charge.	Projectile.		Charge.	Projectile.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
1	22	700	2	25	630
3	22	1,000	9	27	1,000
3	25	1,000	6	39½	800
1	30	630	6	45	1,000
4	35	1,000	5	58	800
1	45	630	3	64	800
2	63½	630	8	73	800
2	63½	800	13	100	800
4	73	630	.....	.....	.....
4	75	800	.....	.....	.....
19	80	630	.....	.....	.....

The firing extended over about nine months, during which interval the springs were about two-thirds of the time under compression.

As at first used each course consisted of 11 springs strung upon a central rod, the course resting upon a plate 1½ inches thick, which in

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turn rested upon a nut screwed upon the rod. Upon the top of the course was a 1-inch plate, and upon this rested the projecting arm of the trunnion carriage. The rod passed out through a plate covering the top of the spring cylinder, resting upon the plate by a nut screwed upon the rod. To increase the compression of the springs this nut was turned, drawing up the rod.

The springs alone of each course occupied a length of 131 inches, or 11.91 inches per spring. After the seventh round with the cast-iron mortar each course was compressed 2½ inches, making the total length of springs 128½ inches, or 11.68 inches per spring, and leaving the total play 21¼ inches, or 1.93 inches per spring. Under this compression the springs returned the piece to the firing position after each discharge, the recoil for the cast-iron mortar being 16 inches, and for the steel mortar 19½ inches.

After firing 11 rounds with the cast-iron mortar, it was dismounted and the steel mortar mounted in its place. At the fourth round with the latter, the third with full charge, the rod upon which was strung the left course of springs parted, and the springs and lower plate being projected downward, struck the turned-in flange at the lower end of the spring cylinder and broke it off, as shown on the inclosed tracing; two nuts attaching the cylinder extension being also broken. Upon dismounting the carriage, the outer coil of the sixth spring of the right course was found to be broken off at the end of the first spire.

Another carriage was mounted and the springs placed in the cylinders without the central rod, the lower end of each course resting upon a plate at the bottom of the cylinder. Eleven springs were used in each course and a sufficient number of Belleville springs, placed "spoon fashion," were added to make the total length of the spiral springs alone 129.5 inches, or 11.77 inches per spring, leaving a play of 22.25 inches, or 2.02 inches per spring. The broken spring was placed at the bottom of the right-hand course.

Under these conditions 6 rounds were fired from a cast-iron mortar without incident, except that the piece was returned rather violently to the firing position, which was found, upon examination, to be due to inefficiency of the counter-recoil buffers, their clearance being too great. This was met by using only ten spiral springs in each course and substituting for the spring taken out six pairs of Belleville springs, filling in until the total length of the ten spiral springs alone was 120 inches, or 12 inches per spring.

Eight rounds were then fired from a cast-iron mortar, after which filling was taken out until the height of the spiral springs was 122 inches, equal to 12.2 inches per spring, and 2 rounds were fired from the steel mortar, at the second of which the right side frame was discovered to be cracked, due to the projection beyond the reenforced guides of the hydraulic cylinders, one of which had probably been struck by the cast-iron piece.

Another carriage was mounted and ten spiral springs were placed in each cylinder, together with six pairs of Belleville springs and filling to make the total length of the spiral springs 122.8 inches, or 12.28 inches per spring, the play of each spiral spring being then 2.53 inches of the ten 25.3 inches, and of the six pairs of Belleville springs 1.42 inches, or total play 26.72 inches.

Nineteen rounds were then fired from a cast-iron mortar, the springs just returning the piece to the firing position after each discharge.

Finally the steel mortar was mounted upon the carriage and 48 rounds fired, after which the carriage was dismantled and the springs

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taken out, showing no signs of deformity or other injury or deterioration. The separating plates, however, were considerably bent, and should be made thicker.

As a result of the test, the Board is of the opinion—That the springs are suitable for use in the spring-return mortar carriage; that no special appliances, other than those employed with the Belleville springs, are necessary for their insertion or use; that they act fully as well when simply confined in the cylinder as when strung upon a rod; that when so inserted that each spring occupies a length of 12.28 inches, they will barely suffice to return the cast-iron mortar to the firing position; that when so inserted that each spring occupies a length of 11.28 inches, they return the cast-iron mortar with a considerable margin of strength; these figures for the steel mortar are respectively 12.47 inches and 12.06 inches; that a spring should not be compressed below a length of 10 inches at the extreme recoil.

An abstract from the firing record is inclosed.

CLIFTON COMLY,
Major, Ordnance Department, U. S. Army,
President.

FRANK HEATH,
Captain, Ordnance Department, U. S. Army.

WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3338–L–'92)

Test of spiral springs, 12-inch mortar, steel, No. 1, on carriage No. 2, B. I. F.

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
75	812	50	18½	18	100	815⅞	50	19½	19⅛
100	817	50	19⅛	19¼	100	817	50	20	13

Test of spiral springs, 12-inch mortar, steel, No. 1, on carriage No. 6, *B. I. F.* / *M. R. C.*

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*
75	775	50	15⅛	15½
100	770	50	13⅜	11⅝

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Test of spiral springs, 12-inch mortar, steel, No. 1, on carriage No. 10, B. I. F

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
25	639 8/16	60	9 1/2	9 3/16	58	817	60	14 1/2	
25	641 8/16	60	10 1/16	10 8/16	58	816	60	15	
25 1/2	1,009 8/16	60	11 1/2	11 1/2	58	815	60	15	
25 1/2	1,011	60	11 1/2	11 1/2	58	813	60	14 1/2	
25 1/2	1,010	60	11 1/2	11 1/2	63 1/2	809	60	15	
27 1/2	1,015 8/16	60	11 1/2	12 1/2	63 1/2	809	60	15	
27 1/2	1,015 8/16	60	12 1/2	12 1/2	63 1/2	809	60	15	
27 1/2	1,014	60	12 1/2	12 1/2	73	811	60	15 1/2	
27 1/2	1,013	45	12 1/2	12 1/2	73	811	60	15 1/2	
27 1/2	1,014	45	12 1/2	12 1/2	73	811	60	15 1/2	
27 1/2	1,018	45	12 1/2	12 1/2	73	816	45	15 1/2	
45	1,019	60	14	14	73	815	45	15 1/2	
45	1,020	60	14	14	73	814	45	15 1/2	
45	1,016	60	14 1/2	14 1/2	73	813	45	16	
39 8/16	809	60	13	13	100	805	60	16 1/2	
39 8/16	811	60	13	13	100	806	60	20 1/2	
39 8/16	811	60	13	13	100	804	60	20 1/2	
45	1,017	45	13	13	100	809	45	20 1/2	
45	1,023	45	14 1/2	14 1/2	100	807	45	18	
45	1,012	45	14 1/2	14 1/2	100	816	45	18 1/2	
39 8/16	807	45	13 1/2	13 1/2	100	815	45	18 1/2	
39 8/16	808	45	13 1/2	13 1/2	100	806	45	18 1/2	
39 8/16	808	45	13 1/2	13 1/2	100	812	50	19 1/2	
58	814	60	14 1/2	14 1/2	100	815 8/16	50	19 1/2	

Test of spiral springs, 12-inch mortar, cast iron, No. 10, on carriage No. 2, B. I. F.

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
30	624	50	9	8	79 8/16	624	40	14 1/2	14 1/2
45	626	50	11 1/2	12	81	633	40	14	14 1/2
63 8/16	630	50	13 1/2	13	81	630	40	14 1/2	15 1/2
73	623	50	14 1/2	13 1/2	81	630	40	15 1/2	16
79	624	50	14 1/2	14	81	625	40	16	16
79	625	45	14 1/2	14 1/2					

Test of spiral springs, 12-inch mortar, cast iron, No. 43, on carriage No. 5, B. I. F

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter Recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
22	627	50	8	8	80	626	50	17 1/2	17
63 8/16	623	50	15 1/2	15 1/2	78 8/16	626	50	18	18
73	630	50	17	16 1/2	78 8/16	624	50	18	18

Test of spiral springs, 12-inch mortar, cast iron, No. 37, on carriage No. 6, B. I. F. M. E. C.

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
22	1,013	65	13	12 3/4	73	800	50	17 1/2	17
22	1,007	65	12 3/4	12 3/4	75	800	40	17 1/2	17
22	1,009	65	13 1/8	12 3/4	75	802	40	17 1/2	17
63 8/16	801	50	17	17	74	797 8/16	40	17 1/2	17

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Test of spiral springs, 12-inch mortar, cast-iron, No. 46, on carriage No. 7, $\frac{B.\ I.\ F.}{M.\ E.\ C.}$

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
35	1,009	60	10⅜	7⅜	78⅝	629	40	16⅛	16⅛
35	1,009	60	10⅜	9¼	78⅝	625	40	16⅛	16⅛
78	625	40	12⅜	10⅛	35	1,008	60	14⅞	15⅛
78⅝	628	40	13⅛	11⅛	35	1,007	60	15	15⅛
78⅛	628	40	16⅛	16⅛					

Test of spiral springs, 12-inch mortar, cast iron, No. 23, on carriage No. 10, B. I. F.

Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.	Charge of powder.	Weight of projectile.	Elevation.	Recoil.	Counter recoil.
Pounds.	*Pounds.*	°	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	°	*Inches.*	*Inches.*
62	780	50	17⅛	16⅜	79	627	50	17⅛	17⅛
71	631⅝	50			79	629	50		
79	631⅝	50	17⅛	17⅛	25	1,013	60	14	14⅝
79	627	50	17	17	25	1,012	60	14⅛	14⅛
79	629	50	17	17	25	1,018	60	14⅛	14⅛

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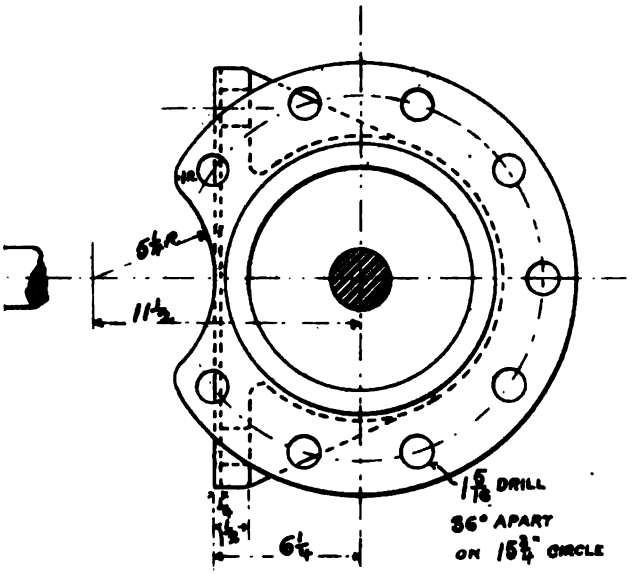
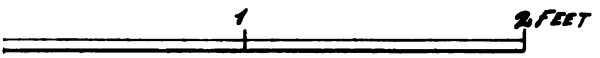


Scale



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The differences in appearance of the smoke were not great; that from Nos. 3 and 4 being somewhat darker than the others, and therefore showed more distinctly against the light-gray sky.

On the following day the same shell were charged as follows:

No. 1, 10 ounces powder.

No. 2, 10 ounces powder and 1 ounce powdered charcoal.

No. 3, 10 ounces powder and one-half ounce lamp black.

No. 4, 10 ounces powder and 2 ounces graphite.

No. 5, 10 ounces powder and 3½ ounces sulphur.

No. 6, 10 ounces powder and 1½ ounces resin.

The volume of powder being 10 in each case against 3 of the other material.

The charges were exploded against a dark background of brush. As before, the differences of color were not decided, but in this case No. 6, powder and resin, appeared the darkest, and therefore the least visible against the brush background. With this exception the smoke in each case was bluish white, and was distinctly visible.

On April 26 the shells, loaded as before, were discharged against a dark-green background of pine trees. On this occasion even less differences than before in the color of the smoke were observable, being bluish white in each case.

From the above-described experiments it appears that it is exceedingly difficult to make a decided change in the color of powder smoke. The nature of smoke in general is such that it is likely to reflect the shorter and refract the longer rays of the spectrum, and thus to appear bluish or brownish according as it is seen against a dark or a light background.

The board is of the opinion that to darken the color of the ordinary powder smoke, which appears to be the only change which it is practicable to make, would not increase its visibility against any ordinary background except the sky, and as it is believed that in service it would ordinarily be projected below the sky line, it is thought that this change would not be desirable.

FRANK HEATH,
Captain, Ord. Depart., U. S. Army (senior member present).

WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(960–A–'94)

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APPENDIX 36.

PROGRESS REPORT UPON EXPERIMENTS MADE TO DETERMINE DIMENSIONS OF CARTRIDGE CASES FOR 3.2-INCH GUN USING SMOKELESS POWDER.

THE ORDNANCE BOARD, U. S. A.,
SANDY HOOK PROVING GROUND,
October 4, 1894.

SIR: Complying with your instructions of September 22, 1894, the board respectfully submits the following progress report upon experiments made to determine the proper dimensions of cartridge case for a charge of smokeless powder for fixed ammunition for the 3.2-inch field gun.

Under date of April 19, 1894, the Department issued a circular letter to the prominent powder manufacturers of the United States, for which see Appendix.

In response to this advertisement, two manufacturers, the Leonard Smokeless Powder Company, of Baychester, N. Y., and the Maxim Torpedo and Powder Company, of Farmingdale, N. J., have delivered samples for test. (The California Powder Works have also given notice of a shipment which has not, however, up to date, come to hand.) In testing these samples the 3.2-inch rifle with Driggs-Schroeder breech mechanism and also that with the Gerdom breech mechanism were used, each being adapted to metallic ammunition and having the same chamber capacity. Considerable difficulty was encountered in finding a practical method of reducing the powder space in the chambers of these guns. The method first adopted was to fill the metallic cartridge case to the necessary depth with a mixture of zinc and antimony, an axial hole being bored through the filling through which the flame from the cap was communicated to the charge. This hole was filled with rifle powder to insure ignition. It was found, however, that on discharge this filling was set back violently against the breechblock, the action on the latter being similar to that due to an excessive powder pressure. The mechanisms of both guns were seriously strained, and it was necessary to abandon this method. The cartridge case was therefore set aside and a solid steel plug was made, the outer dimensions of which were exactly the same as those of the rear portion of the metallic case. This plug could be lengthened by screwing metallic disks to the end; a copper cup was also attached to the end of the plug to act as a gas check. This device has worked well and will be used through out the test.

LEONARD POWDER.

Four samples have been furnished by the Leonard Smokeless Powder Company. They are designated, respectively, W. A. X_{32} cylindrical, W. A. X_{32} tubular, Ruby X_{14} cylindrical, and Ruby X_{14} tubular. The first two are made from the same formula and differ only in that the

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grains of the first are solid, being five-sixteenths inch long and five-sixteenths inch diameter; the second is tubular, seven-sixteenths inch long, three-eighths inch diameter, diameter of hole three-sixteenths inch. The last two are also from the same formula, the first solid five-sixteenths inch long, and nine thirty-seconds inch diameter, second three-eighths inch long, thirteen thirty-seconds inch diameter, diameter of hole three-sixteenths inch. Preliminary firings were also made with a sample on hand of the original Leonard formula. This was found, however, to be too slow for the purpose intended. The results with the four samples submitted were excellent. With a powder space of 62 cubic inches—about one-half the original chamber capacity—a velocity considerably greater than that required was obtained with a pressure not exceeding 26,000 pounds. The tests of these samples will be continued, and it is expected that the standard results can be obtained with a powder space of about 50 cubic inches. The ballistic qualities of this powder are undoubtedly all that could be desired. It contains considerable nitroglycerin. The effects of erosion and its stability are still to be determined.

MAXIM–SCHAPPHAUS.

This powder was furnished by the Maxim Torpedo and Powder Company. It is of a dark-brown color, hard and brittle. It is made in round rods perforated axially with seven holes each one thirty-second inch diameter, diameter of rods three-tenths inch. The samples tested were identical except in the length of the rods, the lengths tried being 5-inch, 1-inch, 0.3-inch, and 0.15-inch, respectively, the latter series giving the best results. This appears to be a very promising powder, and there is no doubt but that with 50 cubic inches of powder space the standard results can be secured.

The stability and erosive effects of this powder have yet to be ascertained.

It is said to be a nearly pure gun-cotton powder, containing but 10 per cent nitroglycerin.

TROISDORFF POWDER.

For comparison with powders of domestic manufacture tests with reduced chamber were made, using the Troisdorff, a foreign powder described in Report of Chief of Ordnance for 1893, page 399. Fair results were obtained, a charge of 17¾ ounces in a chamber of 62 cubic inches capacity giving 1,423 foot-seconds velocity with 30,600 pounds pressure. So far, however, as ballistic results are concerned the powders of domestic manufacture are superior to the Troisdorff, and there is no reason to believe that they are not equal to the latter in other desirable qualities.

Appended to this report are tables giving a summary of all the results obtained up to date in connection with these tests.

FRANK H. PHIPPS,
Major, Ordnance Department, U. S. Army, President.
FRANK HEATH,
Captain, Ordnance Department, U. S. Army.
WILLIAM CROZIER,
Captain, Ordnance Department, U. S. Army.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(2831)

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Kind of gun.	Date.	Weight charge.	Weight projectile.	Chamber. Length.	Chamber. Capacity.	Velocity.	Pressure.	Remarks.
	1894.	*Lbs. Ozs.*	*Lbs. Ozs.*	*Inches.*	*Cu. in.*	*Feet.*	*Pounds.*	
3.2-inch B. L. rifle, steel, No. 1, Driggs-Schroeder breech mechanism.	July 21	0 12 ½ igniter.	16 8	8.6	82.3	1,185 1,174	Less than 18,000.	Smokeless, ½ inch long, ½ inch diameter, hole $\frac{1}{15}$ inch diameter; granulation, 360.
	July 23	0 12 ½ igniter.	16 8	6.3	60.5	1,031 1,038	Less than 14,000.	
	July 25	0 12 ½ igniter.	16 8	6.5	61.8	1,016 1,019	Less than 9,000.	
	July 25	0 12 ½ igniter.	16 8	5.1	48	993 1,014	Less than 9,000.	
	July 25	0 12 ½ igniter.	16 8	5.1	48	973 No record.	7,864	
	July 25	1 0 ½ igniter.	16 8	5.1	48	1,081 1,045	11,104	
3.2-inch B. L. rifle, steel, No. 1, Gerdom breech mechanism.	Aug. 17	1 4 ½ igniter.	16 8	5.1	52.5	1,226 1,232	15,000	
3.2 inch B. L. rifle, steel, No. 1, Driggs-Schroeder breech mechanism.	Sept. 13	1 10 ½ igniter.	13 8	13.1	121.3	Lost. 1,149	Less than 18,000.	Smokeless for field guns. W. A. cannon X_{32}, cylindrical, No. 36, 0.25 inch long; granulation, 756.
	Sept. 13	2 0 ½ igniter.	13 8	13.1	121.3	1,384 1,380	Less than 18,000.	Do.
	Sept. 13	2 8 ½ igniter.	13 8	13.1	121.3	1,599 1,602	16,685	Do.
	Sept. 13	2 8 ½ igniter.	13 8	13.1	121.3	1,972 1,980	22,743	W. A. cannon X_{32}, tubular, No. 50, 0.375 inch long; granulation, 404.
	Sept. 13	2 0 ½ igniter.	13 8	13.1	121.3	1,946 1,950	24,533	Ruby cannon X_{14}, cylindrical, No. 36, 0.25 inch long; granulation, 784.
	Sept. 13	2 0 ½ igniter.	13 8	13.1	121.3	2,005 2,011	27,123	Ruby cannon X_{14}, tubular, No. 50, 0.375 inch long; granulation, 428.
	Sept. 21	1 4 ½ igniter.	16 8	6.2	62	1,124 1,127	Lost, copper jammed.	W. A. cannon X_{32}, cylindrical, No. 36.
	Oct. 3	1 0	16 8	6.2	62	1,213 1,207	16,500	W. A. X_{32}, No. 36, cylindrical.
	Oct. 3	1 12	16 8	6.2	62	1,474 1,468	26,000	Do.
	Oct. 3	1 6	16 8	6.2	62	1,473 1,464	22,000	W. A. X_{32}, No. 50, tubular.
	Oct. 3	1 1	16 8	6.2	62	1,319 1,310	18,093	Ruby X_{14}, No. 36, cylindrical.
	Oct. 3	1 4	16 8	6.2	62	1,445 1,438	21,029	Do.
	Oct. 3	1 3	16 8	6.2	62	1,575 1,566	24,825	Ruby X_{14}, No. 50, tubular.

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Kind of gun.	Date.	Weight charge.	Weight projectile.	Chamber. Length.	Chamber. Capacity.	Velocity.	Pressure.	Remarks.
	1894.	*Lbs. Ozs.*	*Lbs. Ozs.*	*Inches.*	*Cu. in.*	*Feet.*	*Pounds.*	
3.2-inch B. L. rifle, steel, No. 1, Driggs-Schroeder breech mechanism.	Sept. 18	1 0 ½ igniter.	13 8	13.1	121.3	1,047 1,036	Less than 9,000.	Rods of powder cut 4 inches long.
	Sept. 18	1 10 ½ igniter.	13 8	13.1	121.3	1,374 1,380	12,420	Do.
	Sept. 18	2 0 ½ igniter.	13 8	13.1	121.3	1,626 1,626	17,693	Do.
	Sept. 18	2 8 ½ igniter.	13 8	13.1	121.3	2,065 2,060	30,133	Do.
	Sept. 18	2 9½ ½ igniter.	13 8	13.1	121.3	2,128 2,131	34,231	Do.
	Sept. 18	1 0 ½ igniter.	16 8	6.2	62	1,170 1,171	16,208	Rods of powder cut 5 inches long.
	Sept. 18	1 0 ½ igniter.	16 8	6.2	62	1,151 1,151	16,145	Do.
	Sept. 20	1 4 ½ igniter.	16 8	6.2	62	1,395 1,402	23,800	Do.
	Sept. 20	1 4½ ½ igniter.	16 8	6.2	62	1,382 1,387	22,508	Do.
	Sept. 20	1 5½ ½ igniter.	16 8	6.2	62	1,561 1,569	32,800	Do.
	Sept. 20	1 5 ½ igniter.	16 8	6.2	62	1,549 1,551	33,907	Do.
	Sept. 20	1 0 ½ igniter.	16 8	6.2	62	Lost. 1,125	16,042	Rods of powder cut 1 inch long.
	Sept. 20	1 4 ½ igniter.	16 8	6.2	62	.....	22,609	Do.
	Sept. 21	1 0 ½ igniter.	16 8	6.2	62	1,106 1,111	15,000	Rods of powder cut ⅛ inch long.
	Oct. 3	1 4	16 8	6.2	62	1,329 1,322	20,853	Rods cut 1 inch long.
	Oct. 3	1 6	16 8	6.2	62	1,487 1,477	26,433	Do.
	Oct. 3	1 6	16 8	6.2	62	1,528 1,517	28,957	Rods cut $\frac{3}{16}$ inch long.
	Oct. 3	1 0	16 8	6.2	62	1,210 1,204	16,211	Rods cut $\frac{1}{16}$ inch long.
	Oct. 3	1 3	16 8	6.2	62	1,380 1,371	22,920	Do.

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TROISDORFF SMOKELESS POWDER.

[Mark IV. Granulation 51,147.]

					Approximate.			
3.2-inch B. L. rifle, steel, No. 1, Driggs-Schroeder breech mechanism.	July 26	0 9 ½ igniter.	16	8	6.2	59.3	975	Less than 14,000.
							1,027	
	July 26	0 12 ½ igniter.	16	8	6.2	59.3	1,092	14,865
							1,066	
	July 26	0 15 ½ igniter.	16	8	6.2	59.3	1,194	20,983
							1,185	
	July 26	1 1 ½ igniter.	16	8	6.2	59.3	1,348	22,000
							1,347	
	July 26	0 11 ½ igniter.	16	8	4.3	39.2	1,093	19,000
							1,065	
	July 27	0 15 ½ igniter.	16	8	5.2	48.6	1,280	24,157
							1,284	
3.2-inch B. L. rifle, steel, No. 1, Gerdom breech mechanism.	July 30	1 1 ½ igniter.	16	8	4.9	48	1,453	35,183
							1,452	
	Aug. 17	1 0 ½ igniter.	16	8	5.1	52.5	1,419	34,000
							1,425	
	Aug. 17	1 0 ½ igniter.	16	8	5.1	52.5	1,407	34,950
							1,410	
3.2-inch B. L. rifle, steel, No. 1, Driggs Schroeder breech mechanism.	Sept. 20	1 0 ½ igniter.	16	8	6.2	62	1,323	26,014
							1,327	
	Sept. 20	1 1 ½ igniter.	16	8	6.2	62	1,382	28,477
							1,387	
	Sept. 20	1 1½ ½ igniter.	16	8	6.2	62	1,423	30,677
							Lost.	

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APPENDIX 37.

SPECIFICATIONS FOR SMOKELESS POWDERS FOR FIELD, SIEGE, AND SEACOAST GUNS.

[Circular Letter.]

SMOKELESS POWDER FOR 3.2-INCH B. L. FIELD GUN, STEEL, USING METALLIC CARTRIDGE CASE.

OFFICE OF THE CHIEF OF ORDNANCE,
UNITED STATES ARMY,
Washington, D. C., April 19, 1894.

GENTLEMEN: The Department desires to procure at an early date samples of smokeless powder for trial with the 3.2-inch B. L. field gun. The powder will be tested in a gun adapted for a metallic cartridge case with rear ignition. The cartridge case at present available has an interior clear length of 12.15 inches, interior diameter (slightly conical) average 3.53 inches, and a capacity of 114 cubic inches. The total volume of bore of gun, including powder space in case, is 690 cubic inches, nearly; and the travel of shot 68.6 inches.

The object now is to find a smokeless powder for the service of this gun with fixed ammunition and, concurrently, to determine the suitable capacity of cartridge case for the powder. Experiments will be made with samples of powder procured to ascertain the least charge of a powder, otherwise good, and the requisite spacing, adapted to give an initial velocity of about 1,450 foot-seconds with a projectile weighing 16.5 pounds and a pressure not exceeding 30,000 pounds per square inch.

A powder which would be deemed suitable, for ballistic properties, should fulfill these conditions with a considerably reduced powder space over that afforded by the present cartridge case; or, when fired in this case, should give a considerably lower pressure than 30,000 pounds, other conditions remaining the same. No material change can be admitted in the diameter of the present cartridge case, hence whatever reduction of the present powder space may be found practicable will be applied to shorten the length of the case to be designed for service.

Having these conditions in view, you are requested to state a price for delivery to the commanding officer, Sandy Hook Proving Ground, within 30 days after notice of acceptance of bid, of 20 pounds of smokeless powder for 3.2-inch B. L. field gun, with the understanding that the Department will have the privilege of increasing the quantity as may be desired, to an amount not exceeding 250 pounds at the price stated, for early delivery at a subsequent date.

In reply to this letter you are also requested to state at what price you could deliver say 5,000 pounds of powder like your sample.

Respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

Specifications for samples of smokeless powder for 5-inch, 7-inch, 8-inch, and 10-inch breech-loading cannon.

The objects of procuring these samples of smokeless powder are to seek the most suitable types of smokeless powder attainable for service use in the cannon mentioned, and to foster the development of their manufacture in this country. To further these aims the Department will test, free of charge, for the guidance of those whose offers to undertake to furnish these samples may be accepted, a reasonable number of such preliminary samples as they may furnish for this purpose.

The ballistic data of the cannon in question and the standard ballistic requirements for the present service powders are as follows:

	5-inch B. L. rifle.	7-inch B. L. howitzer.	8-inch. B. L. rifle.	10-inch B. L. rifle.
Diameter of powder chamber.....inches..	5.7	7.2	9.5	[illegible]
Clear length of powder chamber.....do....	15.15	7.465	51	[illegible]
Volume of powder chamber.....do....	395.6	3,167	3,616.7	[illegible]
Travel of shot in bore.....do....	119.8	81.25	205.25	[illegible]
Total volume of bore, including chamber, cubic inches.....	2,825	3,500	14,110	[illegible]
Weight of projectile.....pounds..	45	105	360	[illegible]
Powder, present service.....	Sph. hex.	Granular.	Br. prism	Br. prism
Weight of charge.....pounds..	12.5	10	125	[illegible]
Initial velocity.....foot-seconds..	1,830	1,085	1,950	[illegible]
Maximum pressure per square inch.....pounds..	36,000	28,500	37,000	[illegible]

REQUIREMENTS FOR ACCEPTANCE.

Each sample is to consist of an amount estimated as sufficient to furnish ten full charges and must be in one uniform lot. All the powder must be practically smokeless, at least not producing a smoke cloud, of domestic manufacture, and subject to inspection, including test and proof, before acceptance; and it will not be paid for unless it fulfills the requirements herein stated.

Ballistic qualities.—The samples must show the following ballistic qualities for acceptance:

Five-inch siege gun: Initial velocity about 1,830 foot-seconds and maximum pressure not greater than 14 tons (31,360 pounds) per square inch.

Seven-inch siege howitzer: Initial velocity about 1,085 foot-seconds and maximum pressure not greater than 12 tons (26,880 pounds) per square inch.

Eight-inch seacoast gun: Initial velocity not less than 2,000 foot-seconds and maximum pressure not greater than 15 tons (33,600 pounds per square inch.

Ten-inch seacoast gun: Initial velocity not less than 2,025 foot-seconds, and maximum pressure not greater than 15 tons (33,600 pounds per square inch.

Stability.—The powder must be not unduly subject to accidental ignition or explosion or to deterioration under exposure to climatic conditions or in storage. It must also withstand successfully the following test, or an equally sensitive test for decomposition: Heated to a temperature of 150° to 155° F. it must not produce any discoloration of potassium iodide starch paper, partially moistened with dilute glycerin, in less than twelve minutes.

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within the results practically obtainable in the actual most advanced state of the manufacture of these types of powder, and it is desired that the margin thus allowed shall be employed in the development of the following additional qualities, which are considered as essential in a satisfactory service powder:

It should give uniform ballistic results.

It should cause the least practicable erosion of the bore.

It should possess the greatest practicable stability against accidental explosion or deterioration under exposure to climatic conditions and in storage or transportation.

For the seacoast guns, the highest attainable projectile energies, within allowable limits of erosion and pressure, are desired.

For the siege pieces it is not desired to increase the projectile energies above those stated, and improvements in the ballistic qualities should be directed to the reduction of the erosion and the charge.

INSTRUCTIONS TO BIDDERS.

Bids may be made for one or more of the samples required.

Bidders should state the approximate weight of charge which they estimate as suited to fulfill the ballistic requirements, and should make their bids for a number of pounds estimated as sufficient for ten full charges at a stated price per pound, delivered at Communipaw, N. J., and should state how soon after the receipt of the order the powder will be delivered.

Bidders should also state a price per pound for such further quantity, not greater than twice the amount named in the bid, as may be ordered by the Chief of Ordnance, to be delivered as above at an early date after the receipt of the order therefor.

The Department reserves the right to reject any or all bids or parts thereof.

Blank forms on which proposals must be made can be had on application to this office.

Envelopes containing proposals should be marked "Proposals for smokeless powder," and addressed to the Chief of Ordnance, United States Army, Washington, D. C.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance, U. S. A.

OFFICE OF THE CHIEF OF ORDNANCE,
War Department, August 4, 1894.

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APPENDIX 38.

ANNUAL REPORT OF CHIEF ORDNANCE OFFICER, DEPARTMENT OF THE PLATTE.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
OFFICE OF CHIEF ORDNANCE OFFICER,
Omaha, Nebr., June 30, 1894.

GENERAL: I have the honor to submit the following report of the operations of this office and of the Omaha Ordnance Depot during the past year:

OMAHA ORDNANCE DEPOT.

The depot has been maintained, as has been the case for the past three years, simply as a reserve of stores for field service, to be drawn upon only in an emergency. The stores kept on hand are sufficient to reequip about 300 infantry and 200 cavalry. Owing to the impending change in small arms the stock of ammunition has been materially reduced by issues to troops. There are on hand at present only 192,852 rifle and 38,698 carbine ball cartridges, caliber .45. Most of the leather work was oiled this spring, and everything is in readiness to issue whenever needed.

ORDNANCE STORES.

Only one complaint of the quality of the stores furnished by the Department to the Army has been received. Changes have been suggested, as will be noted in the course of this report, but no defects due to bad materials or poor workmanship at the arsenals have been reported to me, except in the case of a rather insignificant article, the paster used in stopping the bullet holes in the targets. The adhesive material used was reported to be insufficient to hold the paster firmly. A special report of the facts was made September 15, 1893, and I was informed that the amount of gum composition used on the pasters will be increased in future. Doubtless there will be no further complaint.

THE CALIBER .38 REVOLVER.

In my last annual report I stated that some defects in the new revolver had been developed. After the termination of the target practice season these alleged defects were investigated and a full report was forwarded September 15, 1893. Directions for the use of the revolver have since been issued, and as the men become more familiar with the weapon they get better results from it. Several cavalry officers have stated that their revolvers work all right and the accuracy is considerably superior to that of the old caliber .45. Others have stated that the mainsprings are too weak and sometimes fail to explode the cartridge.

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instead of to the left. Most officers in this department prefer to have the revolver break to the right, and I concur in this preference. It makes little difference on foot, and it is even probable that with practice, more rapid firing could be done dismounted with a revolver breaking to the left than with one on the reverse plan. The revolver is, however, essentially a weapon for use on horseback, and the reason is plain why the cylinder should open to the right. The reins are held in the left hand and the revolver in the right in firing. It is simply a question as to which hand can be more conveniently emptied so that it can be used to handle the cartridges. I think it is evident that the revolver can be thrown into the left hand much more easily than the reins can be changed to the right. It follows, therefore, that the cylinder should open to the right.

I would recommend that this change be made if the construction of the pistol will admit of it, and that the mainspring be given more power.

CURB BIT, MODEL 1892.

Some of these bits have now been in use in each cavalry troop in this department for nearly a year. So far as I have been able to learn from conversation with officers, they have given entire satisfaction, and troop commanders are anxious to completely equip their horses with them. The bit is simple, handsome, strong, and comfortable for the horse.

U. S. MAGAZINE RIFLE, CALIBER .30, MODEL 1892.

The new rifle has been on exhibition in my office and at Fort Omaha for about two months and has been examined by many officers and civilians. There has been no opportunity to try it at the range as I have no ammunition for it, but its general appearance and action have found much favor. One objection that is frequently made to the gun is that the position of "carry arms" with it is very uncomfortable. The bolt handle does materially interfere with the grasp at the small of the stock. The remedy is, however, plain; the Army must abandon the "carry" altogether. It is also quite probable that the "right shoulder" position should be changed. Certainly no sportsman ever carried his gun while hunting as prescribed in tactics for "right shoulder arms." The tactics must suit the rifle, and they become obsolete as soon as an improved weapon renders them inconvenient.

ENGLISH CAVALRY SABER.

The English cavalry saber, referred to in my last report as under trial by the Ninth Cavalry, was returned to the Ordnance Office November 6, 1893, with an able and exhaustive report by Lieut. A. B. Jackson, of that regiment, which was concurred in by Col. Biddle, commanding the Ninth Cavalry.

I am personally not in favor of furnishing the saber to the enlisted men of the cavalry, as I regard it as practically an obsolete weapon; but if the cavalry officers desire it, I would make it as efficient and satisfactory as possible. I therefore concur in Lieut. Jackson's recommendations that the shape of the guard and the mode of forming the hilt out of the blade in the English saber be adopted, and also the wooden lining and wide mouth piece for the scabbard.

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This ingenious tool, which is a combination of a shovel, hatchet, and pick, was thoroughly tried at Fort D. A. Russell, but did not give satisfactory results. The metal of which the stock of the tool was made was too soft and the wooden handle, dried out by the climate of Wyoming, would not stay in its place. A much better tool can undoubtedly be made on the same principle.

DODGE BLANKET-ROLL SUPPORT.

This equipment was tried by a company of the Second Infantry in competition with the Merriam pack and the blanket bag. The report of Capt. Kinzie, who conducted the test, was very much in favor of the Dodge support. I did not deem the trial by a single company sufficient, and recommended further experiment by several different organizations. This is now in progress at Fort D. A. Russell, where four companies have been supplied with twenty each of the Dodge support and the improved Merriam pack. These are to be thoroughly tried this season in competition with each other and the service blanket bag.

THE "SUREFAST" GIRTH FASTENER.

This device was given a thorough and impartial trial by the Sixth and Ninth regiments of cavalry. The unanimous opinion of the officers who superintended the trial was against its adoption for the service saddle, though it is probably valuable for civilian riding. Its adoption was therefore not recommended.

HEELER RASP.

This blacksmith's rasp, as modified by the manufacturers to suit the requirements of cavalry service, was tried by the Sixth Cavalry. The reports received indicate that the rasp is now very satisfactory, and I would recommend further trial of the rasp on a more extended scale.

ECONOMIC FEED BAG.

This bag has the open end covered with netting except a hole for the horse's nose and is designed to keep the horse from wasting grain. The idea was regarded as a good one by cavalry officers, but the nose bag as a whole was not satisfactory on account of its shape, the insufficiency of ventilation, and the inferiority of its material. It is possible that the ventilated service bag, made on the economic principle, would receive more favor.

ALUMINIUM CARTRIDGE-BELT PLATES.

Ten cartridge-belt plates made of aluminium were sent to Fort Omaha by Lieut. W. C. Brown, First Cavalry, under instructions from the War Department, for trial. The report of Capt. Waring, whose company tried them, was decidedly in favor of the aluminium plate. I concur in the opinion that all parts of the equipment should be made as light as possible, but I have several times pointed out the advantage of doing away with the belt plate entirely for infantry and using a buckle, which might of course be made of aluminium, such as is now supplied with the cavalry belt. It would be lighter, more easily fastened, and much more readily adjusted to the different lengths required when the man changes from the blouse to the overcoat or vice versa.

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TIN CUPS.

I believe aluminium has been suggested for the cup and I think it could be advantageously used for this article of the equipment. Whether the material is changed or not I would strongly recommend that the shape and method of making the cup be modified. The present cup is so deep that it is awkward to carry, and having folded seams any battering causes it to leak. The seams are also starting points for rust. I would recommend a cup 4½ or 5 inches in diameter and 3 inches deep, pressed out of a single sheet of metal, with the handle riveted on.

CAVESSONS AND DUMB JOCKEYS.

The use of these articles is recommended by Lieut. Blunt, in his pamphlet on "Training Remount Horses," and an application was received for a supply of them from one of the troops of the Ninth Cavalry. Upon investigating the subject by obtaining reports from cavalry officers, I found that it was their opinion that it is unnecessary to issue these articles. A halter and lariat will answer all the purposes of a cavesson and strap for longeing a horse, and the use of the crossrein or "dumb jockey" is deemed unnecessary and even objectionable, as calculated to give a horse a hard mouth.

TARGETS.

In an interesting article in the Journal of the Military Service Institution for March, 1894, entitled "Rifle practice in its relation to eye strain," Capt. J. M. Banister, assistant surgeon, U. S. Army, calls attention to some of the defects of the present system of target practice as it affects the eyesight of our men. The only point in the article which requires consideration by the Ordnance Department is that in regard to the color of the targets. Dr. Banister says in his recapitulation: "In the first place, the color of the targets should by all means be changed, and the element of glare reduced to a minimum. This can easily be effected by making the body of the target black and the bull's-eye and rings buff. By this simple change the reflection of light from the target could be almost entirely obviated, since the only visible reflecting surface in this case would be the bull's-eye. Every one knows that the black target will absorb light instead of reflecting it. Another gain in this change would be the greater contrast produced between the color of the target and the face of the landscape, which would be a great advantage at most of our military posts."

It seems to me that this matter is of sufficient importance to warrant some experiments with black targets and buff bull's-eyes and rings.

DISTRIBUTING AMMUNITION TO A LINE OF BATTLE.

Various means have been suggested of carrying ammunition from the train to the men when engaged. Carts and wagons have been devised for the purpose, but so far none of them have been very satisfactory. Since I have been in the Department I have seen a great deal of the use of pack mules, and I am of the opinion that no form of transportation from the wagon train to the line of battle can surpass these animals in efficiency. A pack mule will carry easily 250 pounds, or over 3,000 rounds of caliber .30 cartridges. He can go wherever a man can, and thus take advantage of natural shelter from fire. He could be taken along ravines, behind ridges, through timber, and under cover of buildings, and thus keep out of sight of the enemy.

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The ammunition could be carried in various ways, in boxes like those for the Hotchkiss mountain gun, in suitably arranged panniers or in belts. In conversing with Col. Merriam, the inventor of the Merriam pack, on this subject, he suggested the use of a pack saddle with crosstrees upon which extra belts full of cartridges could be hung. This seems to me an excellent idea. I would suggest the use of belts somewhat longer than the ordinary belt, made endless, without any plate or buckle, and with thimbles for 100 or 200 rounds. They could be suspended over the shoulder in fighting, and might be called battle belts. They should of course be filled at the rear.

Two of these pack mules would probably be sufficient for each company, and they would besides be very useful on the march. They could be used for collecting supplies from the country, to gather wood for the fires, to bring water to a dry camp, and for a thousand other purposes.

RECOMMENDATIONS RENEWED.

I would invite attention to some recommendations that I have made in previous reports.

ARM CHESTS WITH HINGES AND PADLOCKS.

I would recommend that when the new rifle is sent out such chests be furnished with the first equipment for each company.

THE FOUNTAIN CARBINE SCABBARD.

I recommend that this scabbard be used when a new arm is given to the cavalry.

INDIVIDUAL GUN RACKS.

The loss of several revolvers from the troop gun racks in this Department leads me to renew my suggestion of last year that in new barracks arrangements be made for individual gun racks, so that every man can be held strictly accountable for his arms.

SHOTGUNS.

I would recommend that a good double-barreled breech-loading shotgun of 10 or 12 bore be issued instead of the 20-gauge single-barreled gun now issued.

Very respectfully, your obedient servant,

J. C. AYRES,
Captain of Ordnance, Chief Ordnance Officer.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(3541-'94)

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APPENDIX 39.

REPORT BY O. W. ALBEE ON FORGINGS AND CASTINGS FOR SAULT DE STE. MARIE CANAL LOCK GATE, FURNISHED BY MIDVALE STEEL COMPANY, FOR ENGINEER DEPARTMENT, U. S. ARMY.

MIDVALE STEEL WORKS,
Philadelphia, Pa., September 21, 1894.

SIR: I have the honor to submit the following report of the work on the St. Marys Falls Canal lock gate forgings and castings, undertaken by the Midvale Steel Company for the Engineer Department, U. S. Army.

There were 1,542 pieces called for in the contract, for which the Midvale Steel Company made 360 forgings; hence some of the forgings made two or more pieces.

A complete record of ingots cast, hammer treatment, annealing, etc., of the 16 heats cast especially for this work, was kept.

Table A gives the sizes and the number of ingots in each of the 16 heats.

TABLE A.

Heat number.	Size and number of ingots.					
	9 inches square.	13 inches square.	17 inches square.	20 inches square.	30 inches square.	44 inches square.
6. O. H. 290	0	0	10	0	0	0
293	0	0	9	0	0	0
285	0	0	1	0	0	1
286	0	0	1	0	0	1
288	0	0	1	0	0	1
295	0	0	1	0	0	1
296	0	0	1	0	0	1
305	0	0	1	0	0	1
322	0	0	1	0	0	1
1. O. H. 9042	0	4	1	0	1	0
9044	0	4	1	0	1	0
9046	0	4	1	0	1	0
9048	0	4	1	0	1	0
9050	0	4	1	0	1	0
9070	0	15	0	0	0	0
9073	0	14	0	0	0	0
2. O. H. 5109	0	3	0	1	1	0

The last heat was not cast for the canal gate work, but was used in making replacements of forgings condemned or spoiled in machining. Since these ingots were not in the accepted heats, tests were made for each piece used as a replacement.

The bars for testing the heats were turned bars of 1 inch diameter and were 8 inches long between measuring points, the total length of the bars being 12 inches.

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The bars for bending tests were made the same diameter as the tensile bars, but without the shoulder of the latter. Thirty one tensile tests of forgings and 24 bending tests were made to accept the heats.

Table B gives the physical qualities of the specimens, and also the heats accepted on the corresponding bars, with the chemical composition opposite the number of each heat.

TABLE B.

Marks on specimen.	Name of piece.	Gauged Length.	Elastic.	Tensile.	Elongation.	Contraction of area.	Character of fracture.
		Inches.	*Pounds.*	*Pounds.*	*Per ct.*		
SM1PTL	Pintle	8	44,568	75,121	18.10	50.70	Silky
SM2PTL	do	8	39,470	71,810	18.10	39.20	do
SM3PTL	do	8	38,197	79,195	21.05	46.00	do
SM4PTL	do	8	39,470	75,566	21.90	45.30	do
SM5PTL	do	8	39,470	71,300	26.00	44.20	do
SM6PTL	do	8	38,197	71,178	21.50	38.90	do
SM7PTL	do	8	40,744	70,665	22.90	42.10	do
SM2AP	Anchorage pin	8	42,016	77,922	20.00	44.50	Silky; very fine gran. specks
SM3AP	do	8	39,470	78,049	20.40	38.70	do
SM6AP	do	8	38,197	73,848	23.60	41.20	Silky
SM7AP	do	8	39,470	76,140	20.30	41.60	do
SM8AP	do	8	40,744	73,593	20.68	38.70	do
SM10AP	do	8	39,470	74,375	22.80	46.40	do
SM14AP	do	8	39,470	70,029	22.90	47.80	do
SM11FP	Foot plate	8	40,744	70,028	22.60	44.10	do

Marks on specimen.	Name of piece.	Accepts heat No.—	Composition of heats.			
			C.	P.	Mn.	Si.
SM1PTL	Pintle	1. O. H. 9042	.352	.036	.816	.2[illegible]
SM2PTL	do	6. O. H. 290	.374	.049	.573	.1[illegible]
SM3PTL	do	1. O. H. 9050	.355	.048	.849	.1[illegible]
SM4PTL	do	1. O. H. 9044	.342	.036	.927	.1[illegible]
SM5PTL	do	1. O. H. 9046	.293	.045	.729	.1[illegible]
SM6PTL	do	6. O. H. 293	.326	.052	.645	.1[illegible]
SM7PTL	do	1. O. H. 9048	.375	.050	.780	.1[illegible]
SM2AP	Anchorage pin	6. O. H. 286	.480	.050	.660	.2[illegible]
SM3AP	do	6. O. H. 288	.412	.048	.696	.1[illegible]
SM6AP	do	6. O. H. 285	.385	.044	.765	.1[illegible]
SM7AP	do	6. O. H. 295	.443	.048	.708	.1[illegible]
SM8AP	do	6. O. H. 296	.339	.045	.663	.1[illegible]
SM10AP	do	6. O. H. 322	.360	.045	.684	.1[illegible]
SM14AP	do	6. O. H. 305	.449	.039	.651	.1[illegible]
SM11FP	Foot plate	2. O. H. 5109	.360	.036	.696	.1[illegible]

CASTINGS.

The bed-plate castings caused much trouble, but the 10 castings were finally completed, after the Midvale Steel Company had made 20 or more castings; all gave excellent physical results, but several had bad sand spots and were rejected.

The last 7, however, were made without any difficulty.

Bars measuring 2 inches between gauge marks and 0.505 inch diameter, or a cross section of 0.20 square inch, were taken from coupons on each casting.

Table C* shows the results given by the tensile tests and also the chemical composition of the heats. The results are calculated on 1 square-inch section.

I respectfully call your attention to a few of the articles in the specifications and suggest a few changes in the same, which experience on

*Omitted in printing.

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Article 69, division 4, of the specifications says: "The finished product of open-hearth steel shall not average more than eight one-hundredths of 1 per cent of phosphorus, and never exceed one-tenth of 1 per cent." In place of eight one-hundredths of 1 per cent, I would put four-one-hundredths of 1 per cent, and in place of one-tenth of 1 per cent, six one-hundredths of 1 per cent.

Good open-hearth practice need have no difficulty in reaching these limits.

Sulphur is not mentioned and no limits are given, nor is the analysis for sulphur required. Sulphur should be guarded against just as much as phosphorus, and the average percentage allowed should not be over four one-hundredths of 1 per cent, and should certainly be kept below six one-hundredths of 1 per cent.

Tests for copper should be made if there is any suspicion of the presence of copper in the metal. I can not give the amount of sulphur in the forgings because the analysis for sulphur was not made.

TEST BARS.

Article 74, division 4, says: "A sample bar 12 inches long, not more than 2 inches wide, and having a cross section of not less than three-fourths square inch shall be cut from the finished product of every melt. When taken from metal more than 1 inch thick, this sample may be a turned round bar. The tests shall be made on these samples in their natural state without annealing. Tests may be required from each variety of material rolled from the same melt."

This article was later modified by a letter in which it was stated "after annealing, two test bars shall be cut from one of the forgings of each melt of high steel." One of these samples to be tested and fulfill tensile requirements stated in the letter, the other bar to be used for the bending test.

I would suggest that a bar 4 inches between gauge marks be used and that such a bar be taken from every finished piece of any importance.

The acceptance of a heat, especially of high steel, upon the test of one bar from one heat is, in my opinion, a very unsatisfactory and unsafe method of testing.

Table A shows that one heat may contain ingots of widely different dimensions.

The composition and condition of the larger ingots is different from the smaller, and a test bar from one will not properly represent the other. In larger ingots a piece from the bottom will not be of the same composition and texture of one from the top, and should be given a different heat treatment to give the same desired result.

In one heat the test piece had a section of 50 square inches and weighed 356 pounds, while other pieces in the same heat, and which were given the same annealing temperature, had a cross section of 759 square inches and weighed 15,270 pounds.

The anchorage pins and the pintles were tested, as it was thought these pieces would receive as much or more stress than any of the other pieces in this lot of high steel forgings. If the first bar failed, the com-

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pany had the right to reanneal the whole piece and call for a second bar, and then if the test was successful the rest of the pieces in the heat would be given the same temperature in annealing.

The question, then, is whether the rest of the pieces are in as good condition with one annealing as the piece from which the test is taken after two or possibly three annealings.

A test bar from every piece in the final state would abolish all these difficulties and a smaller bar will do just as well, will make less work in cutting out from the piece.

I inclose test reports for each bar, which reports show the stretch for successive loads up to and beyond the elastic limit.

Whenever there was doubt about the character of heat or piece, extra bars were taken, and sometimes the whole piece was cut up for test. Every care was taken to secure the best material.

The Midvale Steel Company was delayed by the coal strike in the spring, but has pushed the work whenever possible.

Very respectfully,

O. W. ALBEE, *M. E.*

Capt. D. A. LYLE,
Inspector of Ordnance, U. S. Army,
Midvale Steel Works, Philadelphia, Pa.

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APPENDIX 40.

SIGHTS FOR 8-INCH CONVERTED MUZZLE-LOADING RIFLE.

(3 plates.)

The accompanying descriptive drawings represent the rear and front sights in use in service with the 8-inch converted muzzle-loading rifles.

Plate I represents the rear or breech sight of present construction as made since 1891. It consists of a tangent scale with level, affixed to a circular base revolving in a plane normal to the axis of the piece, to compensate for inclination of the trunnions. The scale can be moved laterally on its base by means of the translating screw to correct for wind and drift. It is graduated from 0 to 8 degrees, and may be read in elevation to 1 minute of arc by means of the diagonal scale and vernier slide. The slide is operated by a translating screw. The divisions of the deflection scale are equal, each being one one-thousandth of the distance (54 inches) between the front and the rear sights to give an absolute lateral correction of one-thousandth part of the range.

Plate II represents the rear sight of the original pattern described in Ordnance Memoranda No. 24 (1884), as modified to conform as nearly as practicable to the improvements introduced in 1891. The alterations include an increase in the number of divisions on the tangent scale, each degree being now divided into 12 instead of only 4 parts, so that a direct reading of 5 minutes in elevation can be taken. The former deflection scale of arbitrary divisions in parts of an inch is removed and is replaced by a scale of one one-thousandth, as in the pattern of 1891. The sights of both patterns are made interchangeable in the sight brackets by enlarging the shank of the 1884 pattern to fit the sockets of the sight brackets of 1891, and the sockets of the older pattern brackets are enlarged to be identical with those of 1891.

Plate III represents the front sight, which is a single piece fastened to the gun by two screws, its upper extremity terminating in a blade. The pattern is the same for use with both descriptions of rear sight.

ORDNANCE OFFICE, WAR DEPARTMENT.

(6126–'93)

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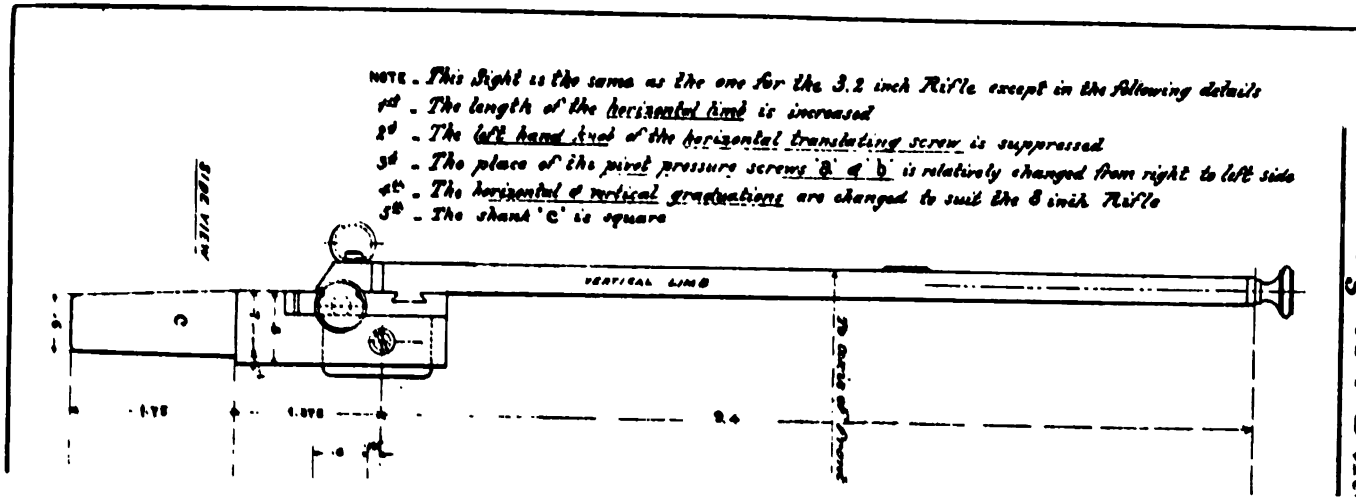
NOTE - This Sight is the same as the one for the 3.2 inch Rifle except in the following details
1st - The length of the horizontal limb is increased
2d - The left hand end of the horizontal translating screw is suppressed
3d - The place of the pivot pressure screws 'a' & 'b' is relatively changed from right to left side
4th - The horizontal & vertical graduations are changed to suit the 8 inch Rifle
5th - The shank 'C' is square
SIDE VIEW
VERTICAL LIMB
C
1.75
1.375
2.4

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WATERTOWN ARSENAL.

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